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AUGUST, 1904.

## CONTENTS.


| | PAGE |
|---|---|
| Turning Tires and Finishing Piston Rods | 291 |
| Engine Failures | 291 |
| Water Purification | 291 |
| Locomotive and Car Shops P. & L. E. R. R. | 292* |
| Progress in Passenger Cars | 295 |
| Internal Friction of Locomotives | 295 |
| Possibilities of the Motive Power Officer | 296 |
| Mallet Compound Locomotive, Details | 297* |
| Personals | 298 |
| Shop Equipment, W. S. Cozad | 299 |
| Steel Underframe Coal Car | 301* |
| Locomotive Testing Plant at St. Louis | 301 |
| Motors Applied to Old Machine Tools | 303* |
| Editorial Correspondence, G. M. Basford | 304 |
| Improved Fire Door Flange | 306* |
| Opportunity of the Engineer | 306 |
| Railroad Progress | 306 |
| Regulating and Reversing Controllers | 307* |
| Test of a Motor-Driven Planer | 308* |
| Compressed Air Flanging Clamp | 309* |
| Educate Your Successors | 309 |
| Porosity Test for Paints | 309 |
| Railroad Mileage of the World | 309 |
| Fuel Economy in Locomotives | 309 |
| Age of the American Engineer | 310 |
| Apprenticeship | 310 |
| Growth of Locomotives in Thirty-seven Years | 310 |
| Long Staybolts, Leaky Flues and Wide Fireboxes | 311 |
| New Design of Lathe Headstock | 313* |
| Pooling of Locomotives | 313 |
| Roller Bearing for Line Shafts | 313 |
| Chucks for Boring and Turning Rod Packing | 314* |
| Locomotive Terminals | 314 |
| Sturtevant Economizer | 315* |
| Overloaded Freight Cars | 315 |
| Machine Tools for Railroad Shops | 316* |
| Independent Multiple Drill | 317* |
| McCanna Force Feed Lubricator | 318* |
| Grinding Machine for Triple Valve Pistons | 320* |
| Allfree-Hubbell Valve Gear | 320* |
| Books and Pamphlets | 321 |
| Notes | 322 |
| Master Mechanics' Association Reports | 323 |
| Locomotive Frames | 323 |
| Variable Speed Motors | 324 |
| Boiler Design | 325* |
| Cost of Locomotive Repair Shops | 326 |

*ILLUSTRATED ARTICLES.


## TURNING TIRES AND FINISHING PISTON RODS.

TO THE EDITOR:

Some months ago you printed a statement of the time consumed in turning locomotive tires in the shops of the Chicago Great Western Railway to the effect that three pairs were turned per day; but you did not state the number of hours. A pair of 56-in. flanged tires have been turned in the Union Pacific shops at Omaha, in 1 hour, 45 minutes, including the time from picking them up to setting them down finished.

An extension piston rod is centered, straightened, roughed, finished and threaded, for $2.60.

Tires are bored for 30 cents each, including the time required for handling.

These figures may interest your readers.

GEO. W. THOMPSON.

These figures will interest our readers. We shall be glad to know of records as good or better.—EDITOR.

## ENGINE FAILURES.

TO THE EDITOR:

The editorial in your May number entitled, "What Are Your Locomotives Doing?" the remarkable series of letters in your June number on the subject of overloading locomotives and your references to foreign practice in the matter of preventing engine failures lead me to send you a statement covering our failure report for the month of April.

With power in good order the cost of operation must necessarily be materially decreased. I believe, as suggested by you, that with first-class supervision in the care of locomotives, the failures can be lessened quite materially and in fact done away with altogether, more especially delays that originate from steam failures caused from so called "poor fuel." We do not experience a failure from this particular cause from one month's end to the other and in fact we have not had a steam failure that can be attributed to the quality of the coal in the last two years.

The following comparison may interest the readers of the AMERICAN ENGINEER AND RAILROAD JOURNAL:

RECORD OF ENGINE FAILURES, MONTH OF APRIL, 1904.

| Date | Eng. | Train | Location | Engineer | Delay. Hrs. | Min. | Cause. |
|---|---|---|---|---|---|---|---|
| 29th | 53 | 8 | On run | ..... | 0 | 20 | Steam pipes leaking. |

CLASSIFICATION OF FAILURES.

| | |
|---|---|
| Steam failures | 1 |
| Total | 1 |
| Unavoidable failures | 1 |
| Could have been avoided | 0 |
| Employes disciplined for failures | 0 |
| Total delays all failures | 20 min. |
| Total number tons reduced | None |
| Average delay per failure | 20 min. |
| Average number tons reduced per failure | None |
| Mileage passenger engines | 94,570 |
| Mileage freight engines | 96,372 |
| Miles run per failure, passenger | 94,570 |
| Miles run per failure, freight | 96,372 |
| Total mileage, all engines | 232,730 |
| Average monthly mileage, all classes | 2,804 |
| Number engines in service | 83 |

COMPARISON.

| | Apl. '04. | Mch. '04. | Apl. '03. |
|---|---|---|---|
| Total number failures | 1 | 7 | 14 |
| Total delays all failures | 20m. | 20h. 40m. | 58h. 45m. |
| Total number tons reduced | None. | 5,730 | 957 |
| Average delay per failure | 20m. | 2h. 37m. | 4h. 12m. |
| Average number tons reduced per failure | None. | 819 | 68 |
| Mileage passenger engines | 94,570 | 92,360 | 77,661 |
| Mileage freight engines | 96,372 | 89,531 | 115,900 |
| Miles per failure, passenger | 94,570 | 92,360 | 12,943 |
| Miles run per failure freight | 96,372 | 12,790 | 14,375 |
| Total mileage, all engines | 232,730 | 222,507 | 227,473 |
| Average monthly mileage, all classes service | 2,804 | 2,589 | 2,774 |
| Number engines in service | 83 | 77 | 82 |

Engine failures may be reduced by close attention and hard work, but the results pay for the effort.

GENERAL MASTER MECHANIC.

## 186,000 GALLONS OF WATER AND TONS OF SCALE.

*To the Editor:*

On a trunk line connecting New York with Chicago there is a water station where it is estimated 186,000 gallons of water are used in every twenty-four hours. This water, according to analysis, contains 34.67 grains per gallon of solid material, of which 31.77 grains are scale-making. This means that in every thousand gallons of water there are 4.54 lbs. of scale-making material, and in 186,000 gallons there would be 844.44 lbs. In one month of thirty days this would amount to over twelve and one-half tons of scale-making material going into locomotive boilers, and month after month at this point tons of scale-making salts find their way into the engines which take water at that place.

The above illustration of the amount of scale-making material a bad water contains is not by any means extravagant, as there are numerous waters containing a far higher percentage.

A locomotive costs on an average $15,000 and for such an expensive machine there should be nothing but the best treatment, not only in regard to its handling, but also in the selection of its food and drink, which is the coal and water, which should be sufficiently pure to get the best results; for like a human being a large percentage of impurities cause the machine to clog up, with various complications setting in, such as corroded sheets, scale-covered tubes, with other internal complications, from which this valuable piece of apparatus is put out of business and shopped for repairs.

It is estimated that the average locomotive uses 5,000,000 gallons of water per year. As such an enormous amount of material is used it would seem as though it ought to have the most careful study as regards its action in the locomotive boiler from the point of view of economy and efficiency.

The action of the different impurities in the water are somewhat similar to the action of different drugs on the system, some causing more trouble than others. The incrusting solids are calcium carbonate, calcium sulphate, calcium chloride, magnesium carbonate, magnesium sulphate, magnesium chloride, iron, alumina and silica. The calcium carbonate, magnesium carbonate, iron alumina and silica give a mud or sludge in the boiler. The calcium sulphate and magnesium sulphate and chloride give a hard scale. The last two, however, must be first decomposed and changed to magnesium oxide. The calcium chloride and magnesium chloride are corrosive

solids. The non-crusting solids, alkali sulphate, alkali chloride, alkali carbonate, are only troublesome when present in too large quantities when they produce foaming. The alkali carbonate, if present in small amounts, is helpful by neutralizing the action of the scale-making salts by changing them to carbonate when they are precipitated as a light mud.

For a great many years it has been fully realized that something ought to be done to put off or alleviate the laying aside of this august patient, the locomotive, in the erecting shop, either for temporary or general repairs. Consequently large doses of various salts and concoctions have been forced into the internal organs of this faithful but much abused locomotive by the most unexpected way through the tank in which these various salts are dissolved and in an unexpected manner they are led by the injector, which by suction rushes the dissolved soda-ash or other salt into the presence of its foes, calcium carbonate, calcium sulphate, calcium chloride, magnesium carbonate, magnesium sulphate and magnesium chloride, and then the fight is on. Molecules of soda-ash, which is carbonate soda, attack molecules of sulphate of lime and form molecules of sulphate of soda and carbonate of lime. The former salt, sulphate of soda, is harmless unless in large quantities and goes out of sight in the water. The carbonate of lime is light and can be blown out and does not cause as much trouble as sulphate of lime. In this fight other scale-making salts are attacked and changed from scale-making and corrosive to much less harmful salts. These different molecules of calcium, magnesium, carbonic acid, sulphuric acid, hydrochloric acid, were troublesome in their former combination as carbonates, sulphates and chlorides of calcium and magnesium, yet, in the presence of soda-ash, which is a purifier, and at high temperature as in the locomotive boiler, it tears apart and forms new compounds which are not as dangerous and troublesome to the engine and helps to keep off the fatal sickness caused by the scale which is being taken in by the several thousand gallons of water used each day. In the water mentioned above, 1,000 gallons contained 4.54 lbs. of scale-making material, and in the 186,000 gallons used in one day it equaled 844.44 lbs., which in one month of thirty days amounted to 12½ tons. If treated before it entered the boiler, probably about 3.7 lbs. per 1,000 gallons, 688.2 lbs. for the 186,000 gallons and about 10 tons for the month, of scale-making material would be removed.

It would seem, therefore, that the treatment of water before allowing it to enter the locomotive boiler would be economical and secure greater efficiency for the engine.

As was said before, it has been estimated that the average locomotive uses 5,000,000 gallons of water a year. Supposing the water used contained on an average 7, 14, 21, 28, 35 and 42 grains per gallon of scale-making material, which would equal for the year, 5,000, 10,000, 15,000, 20,000, 25,000 and 30,000 lbs. to be blown out, washed out or left behind to cover the inside of the boiler. The blowing and washing out cost money and time and the scale formed on the tubes and boiler necessitates the use of larger amounts of fuel and thereby increased expense. It has been said one-sixteenth of an inch of scale on the inside of a boiler necessitates the consumption of 12 per cent. more fuel to generate the same amount of steam, one-quarter of an inch of scale requires 38 per cent. more fuel, while three-quarters of an inch of scale causes a loss of 90 per cent. of fuel.

The above, if only partially true, in actual practice would not only be expensive, but tend toward overloading the digestive apparatus, and if the coal was as poor as some I have analyzed it would tend to produce a case of acute dyspepsia in the firebox, which, while causing only temporary troubles, yet cannot be lost sight of.

W. B. LANDON,
Chemist Erie Railroad.

Meadville, Pa.

## NEW LOCOMOTIVE AND CAR SHOPS.

McKEES ROCKS, PA.—PITTSBURG & LAKE ERIE RAILROAD.

### VII.

#### DISTRIBUTION OF POWER.

As stated in one of the earlier numbers of this series of articles, elaborate provisions were made for the distribution of power to the various shop buildings of the McKees Rocks shops by electrical transmission. It is thought that the many special features and radical departures from former practice involved in this installation will be of more than usual interest, and the plans are herein carefully reviewed. The details of the electrical system of distribution are very completely shown on the accompanying diagram.

The incandescent lights and the constant-speed motors for certain of the machine tools, the cranes, and for the heating, ventilating and blast fans, are operated at 240 volts. The arc lights, as was noted in the article on the power house (May, 1904, page 173), are operated at 120 volts, which necessitated the installation of a 3-wire system and rotary balancer.

The machine tools, which are driven by variable-speed motors, on the multiple voltage system, are divided up into three groups, the division being such that each group requires about the same amount of power and is on a separate circuit. The advantage of this is that if anything should get out of order on one of these circuits only one-third of the tools in the shop will thus be affected, and, moreover, the difficulty can be more easily located than if all the tools were on the same circuit.

The wires are carried from the switchboard in the power-house to the long wire duct or tunnel in the machine shop, through terra cotta conduits. The location of these conduits, as well as the wire tunnel and also of the wire boxes, which lead from the tunnel, are shown on the floor plan of the machine and erecting shop, which was presented on page 454 of the December, 1903, issue. This long wire tunnel, which extends the full length of the machine shop, is 3 ft. 6 ins. wide, 4 ft. deep, and its walls and floor are of concrete. At every 8 ft. 3 ins. along each side of the tunnel, two wooden blocks are built into the concrete, one near the top and the other near the bottom of the wall. Upright planks are fastened to these blocks and carry the wrought-iron clamps for supporting the wires. The wires for the arc and incandescent lighting are supported on one side of the tunnel, and those for the machine tool motors and power on the other side.

The wire boxes, which lead from the tunnel and which carry the wires for the machine tool motors and incandescent lights, are 12 ins. wide and 5 ins. deep. Their centres are only 5 ft. 6 ins. apart, and they extend crosswise of the machine shop for its full width. Those wire boxes on each side of the columns, which support the roof trusses, extend into the erecting shop, and are stopped off about opposite the middle of the pits. The construction of the wire boxes is described and illustrated in connection with the description of the machine shop floor in the December, 1903, issue, pages 455-456.

The wires to each tool are carried through the wire boxes in insulated pipe (loricated conduit). The wiring was done after the floor was laid and, as the tunnel is not very wide and the pipes would of course have to be put in from that end, it was necessary to put them in in 5-ft. lengths and couple up enough of these lengths to reach the desired point. An elbow was then put down through a hole in the floor and connected to the end of the pipe. The pipe was guided into the elbow by passing a piece of rope of about the same diameter as the inside of the pipe through the elbow and drawing the rope into the pipe a short distance by means of a "snake." The straight lengths of pipe were coupled together quite securely, but the elbow was not tightly secured, so that if at any time it was desired to remove the pipe it could easily be disconnected at the elbow and then removed piece by piece. The pipes to the variable-speed motors each contain six wires, four for the multiple voltage system and two for the incandescent light.

In locating the machine tools in the machine shop no attention was paid to the location of the wire boxes. When the tools were connected up it was found that owing to the short distance between the wire boxes the wires in all cases could

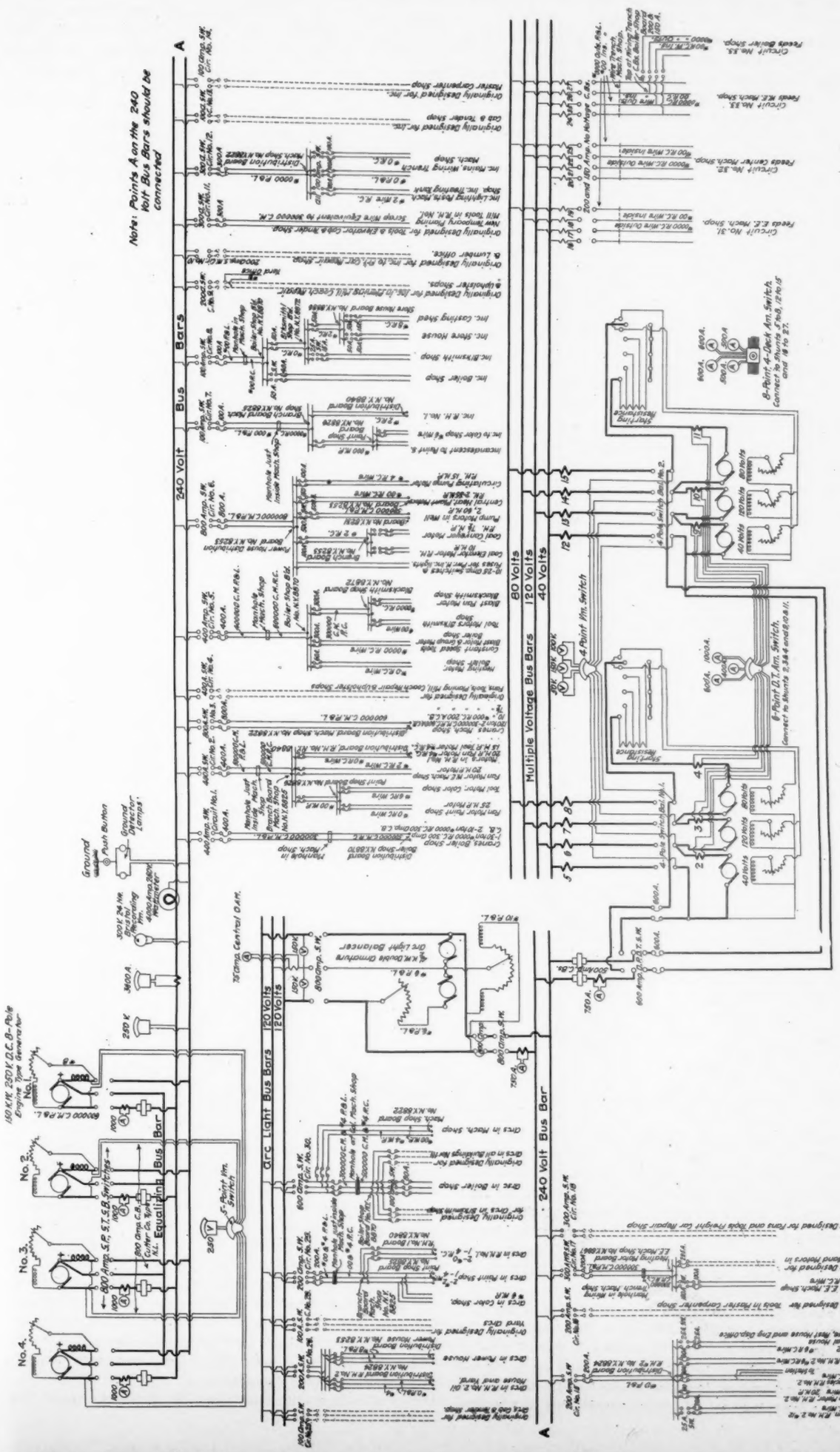

Note: Points A on the 240 Volt Bus Bars should be connected
240 Volt Bus Bars
Multiple Voltage Bus Bars
80 Volts
120 Volts
40 Volts
Arc Light Bus Bars
120 Volts
120 Volts
240 Volt Bus Bar
Equalizing Bus Bar
Ground
Push Button
Ground Detector Lamps.
150 K.W. 250 V. D.C. 8-Pole Engine Type Generator No. 1
No. 2
No. 3
No. 4
800 Amp. S.P., S.T. S.B. Switches
800 Amp. C.B.
5-Point Hm. Switch
4-Point Hm. Switch
4-Pole Switch Bd. No. 2.
8-Point 4-Deck Arm. Switch. Connect to Shunts 5 to 8, 12 to 15 and 16 to 27.
8-Point D.T. Arm. Switch. Connect to Shunts 2, 3 & 4 and 8, 9 & 10.
Starting Resistance
Circuit No. 33. Feeds Boiler Shops.
Circuit No. 32. Feeds M.E. Mach. Shop.
Circuit No. 30. Feeds Center Mach. Shop.
Circuit No. 31. Feeds E.E. Mach. Shop.
Originally Designed for Frame and Tank Freight Car Repair Shop
Originally Designed for Arc Light Generator
Originally Designed for Arc Light Distribution Board
Originally Designed for Tools in Master Carpenter Shop
Originally Designed for Arc Lights in Boiler Shop
Originally Designed for Arc Lights in Blacksmith Shop
Originally Designed for Arc Lights in Machine Shop
Originally Designed for Arc Lights in Erecting Shop
Originally Designed for Arc Lights in Planing Mill
Originally Designed for Arc Lights in Paint Shop
Originally Designed for Arc Lights in Car Shop
Originally Designed for Arc Lights in Tinner Shop
Originally Designed for Arc Lights in Color Shop
Originally Designed for Arc Lights in Flanger Shop
Originally Designed for Arc Lights in Power House
Originally Designed for Arc Lights in Oil Building
Originally Designed for Arc Lights in Store House
Originally Designed for Arc Lights in Casting Shed
Originally Designed for Arc Lights in Blacksmith Shop
Originally Designed for Arc Lights in Upholstery Shops
Originally Designed for Arc Lights in Lumber Office
Originally Designed for Arc Lights in Planing Mill Coach Shops
Originally Designed for Arc Lights in Cab & Tender Shop
Originally Designed for Arc Lights in Master Carpenter Shop

DIAGRAM SHOWING ELECTRICAL DISTRIBUTION OF POWER.

McKEES ROCKS SHOPS—PITTSBURGH & LAKE ERIE RAILROAD.

be brought through the floor at about the right spot, to be most convenient.

This method of wiring the machine tool motors has several advantages. The wires are placed under the floor, where they are entirely out of the way and yet are easy of access if they need attention. New tools can readily be added at any point in the shop and can be wired without tearing up the floor.

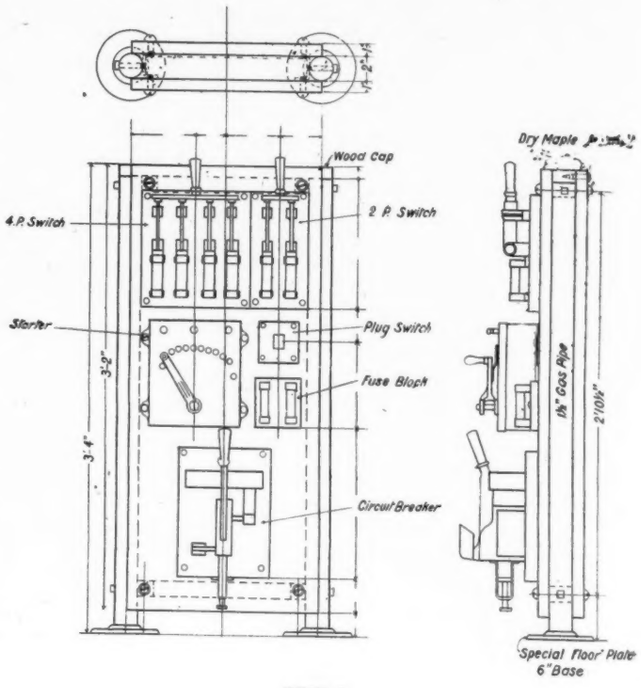
Each tool is furnished with a panel board, which carries the switch, fuse block, circuit-breaker and a plug switch for an incandescent light. In most cases the controller is placed on the machine tool itself at the most convenient point for the operator, but in the case of some tools, such as the shapers, which were described in the July, 1904, issue, page 261, the panel board can be so placed that the controller can be attached to the back of it and at the same time be convenient to the operator. As it is very seldom necessary for the operator to use either the switch, fuse block, circuit-breaker or plug switch, the panel, when it contains only this apparatus, is usually placed in an out-of-the-way position where it will not interfere with the movements of the operator and yet be close to the tool so that it can readily be reached if necessary; it is, of course, also placed so that passers-by will not carelessly come in contact with the apparatus on it.

The use of these panel boards is to be preferred to the practice of placing the above-mentioned apparatus on the frame or bed of the machine tool. It presents a much neater appearance, allows a standard arrangement of the apparatus, and simplifies the wiring. The panel boards, as used at McKees Rocks, are of a very neat and substantial design, and are so fastened to the floor that they are very stiff. The three types of panels which are used are shown in the accompanying drawings. The designs of the panels are practically the same, except that there is a difference in size due to the additional apparatus, which must be carried in some instances.

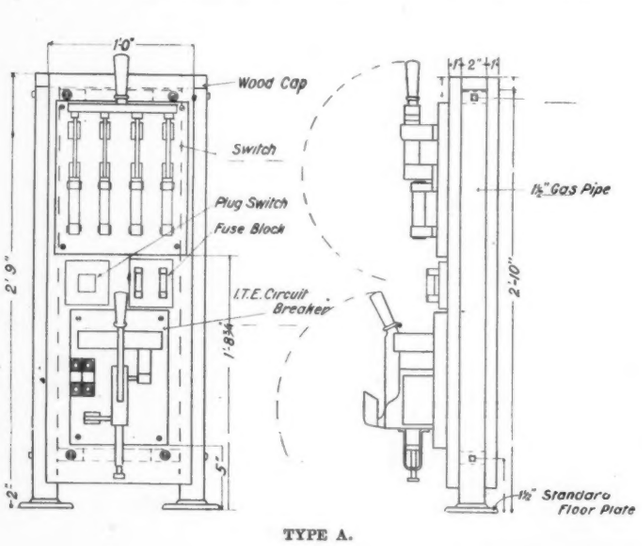
Panel A is the type which is used in the greater number of instances. The dry maple boards are fastened to the wrought-iron straps which are bolted to the pieces of 1½-in. gas pipe. The pipes are firmly attached to the floor by means of 1½-in. standard floor plates, which are fastened to the floor by four lag screws. The opening between the boards at the top is closed by a wooden cap, and the electrical apparatus is located as shown.

Panel B is practically the same as A, except that it is arranged to carry a controller on one side.

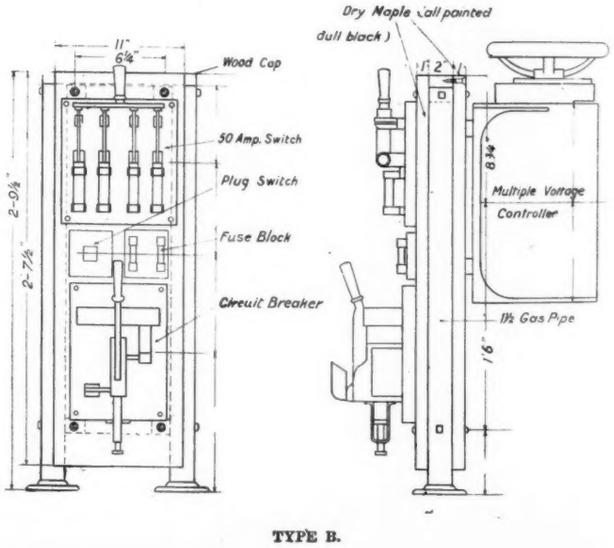
Panel C is used with tools which are equipped with an auxiliary constant-speed motor in addition to the motor for the main drive. It carries in addition to the switch, circuit-breaker and fuse block for the main motor and the plug switch for the light, a starter and switch for the constant-speed motor. To insure stiffness for this panel, which is considerably larger than the others, special 6-in. floor plates are used. Such a panel is used with the Pond car wheel borer (May, 1904, page 193), which has an auxiliary motor for the hoist, and also with the Pond 72-in. boring mill (May, 1904, page 193), which has an auxiliary motor for raising and lowering the cross rail.




TYPE C.




TYPE A.




TYPE B.

MACHINE TOOL PANEL BOARDS FOR ELECTRICAL APPARATUS.

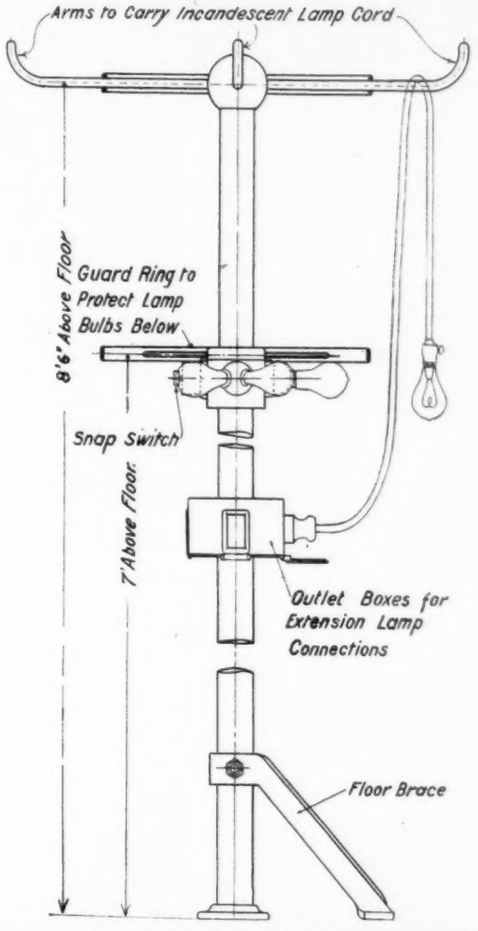
Circuit-breakers are placed at each machine tool in order to fully protect each tool. Where this is not done and only one breaker used in a circuit a motor might become dangerously overloaded at one of the tools and the tool be injured without overloading the circuit enough to throw out the breaker, particularly if the other tools on the circuit happened to be running light at the time.

The electrical apparatus on the panel boards was selected with a view to strength and durability. The circuit-breakers are the I. T. E. type, manufactured by the Cutter Manufacturing Company. The fuse blocks are the Noark cartridge type, manufactured by H. W. Johns-Manville Company, New York. The switches are of a special design, and were made by the W. S. Hill Electric Company.

The wiring at the machine tools, from the panel board to

the controller and motor, has been very nicely taken care of, and deserves special notice. The wires are enclosed in loricated conduit and in some special cases in a flexible conduit. This protects them and keeps them out of the operator's way and also presents a very neat appearance. Although the panel boards, controller and motor are in most cases placed at different parts of the tool yet the wires which connect them are not in evidence except at the motor connection. The pipe which carries the wires is painted the same color as the tool and in most cases is so placed that it would hardly be noticed unless attention was particularly directed to it.

Examples of the method of wiring some of the tools and of the location of the panel boards, etc., is quite clearly shown on some of the half-tones which were used in illustrating the series of articles which have appeared in the AMERICAN ENGINEER on "The Application of Individual Motor Drives to Old Machine Tools at the McKees Rocks Shops." Fig. 22 on page


Arms to Carry Incandescent Lamp Cord
8'6" Above Floor
Guard Ring to Protect Lamp Bulbs Below
Snap Switch
7' Above Floor
Outlet Boxes for Extension Lamp Connections
Floor Brace

LAMP POST USED BETWEEN PITS IN ERECTING SHOP.

441 of the December, 1903, issue shows quite clearly the manner of wiring one of the vertical drill presses. The panel board could not be placed directly over the wire box, and the pipe containing the wires is turned to the left after it comes through the floor. The pipe passes from the back of the panel board up alongside the motor brackets and over to the controller. The wires to the motor pass through the short length of pipe which is connected to the above pipe by a junction box, which is located directly above the motor. The panel board is the same as Type A. Another panel of this same type is shown on page 14 of the January, 1904, issue in connection with one of the slotters.

Another example of the wiring is plainly shown on the radial drill press, illustrated on page 54 of the February, 1904, issue. The motor, controller and panel board are all carried on the revolving part of the tool. A long piece of flexible conduit, which is manufactured by the Western Electric Company, extends from the floor to a junction box, from which pipes lead to the panel board, controller and motor. On Figs. 37 and 42, pages 88 and 89, of the March, 1904, issue, the wiring of two of the turret lathes is partially shown. In these cases flexible conduits are used for carrying the wires from the controller to the motor. Other examples of wiring are shown on the driving wheel lathe, page 129, April, 1904, issue, and on the planers, page 214, of the June, 1904, issue.

In the boiler shop the feed wires are carried overhead. Most of the machine tools are arranged along one of the side walls, and the connection to these tools is made through pipe which passes down along the wall.

LIGHTING.

In the erecting shop arc lights are hung half way between the pits, alternating one at each side of the bay; also one arc at every third truss above the traveling cranes. In the machine shop there is a row of arcs down the middle of each bay, an arc being placed in every other space between roof trusses. Alternate spaces are used in the two bays. In the boiler shop arcs are placed every 55 ft. along the side walls and in the centre of the shop. The lights in the row down the centre are staggered with those in the side rows.

Each machine tool is furnished with an extension cord and an incandescent light. The cord is a twin-wire conductor, built up round about ½-in. diameter and armored with light steel braid. Each light socket is fitted with a clamp, which is a modified form of "electrogrip," made of specially heavy material.

At the centre of each work bench between the pits in the erecting shop is a lamp post, a general outline of which post is shown in the accompanying cut. About 7 ft. above the floor is provided a cluster of five lights and a snap switch. Below this is a 4-point outlet box for extension cords, and at the top of the post, 8 ft. 6 ins. above the floor, are four arms, over which the extension cord can be thrown, so that if a man is using the light about the locomotive the cord will be held up out of the way of passers-by. The cluster of lights are protected from this cord by the wrought-iron ring just above them. The details of construction of this special post are clearly shown in the drawing. Portable lamp posts have also been fitted up for use in the various shops.

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PROGRESS IN PASSENGER CARS.—Thirty-five years ago the average coach would carry from thirty to forty-five passengers and weighed about fourteen tons; the cars were equipped with link and pin couplers; were carried on 4-wheel trucks with journals 3½x6 ins.; were lighted with oil lamps; had small windows; in some cases were without a clear story, and were heated with wood-burning stoves. The cost of a coach such as I have described was about $3,500. To-day our standard coach is 72 feet long over end sills; weighs from 52 to 55 tons; has a seating capacity of 86 passengers; is carried on 6-wheel trucks, with journals 5x9 inches; has steel platforms and wide vestibules; is heated with steam heat and lighted with gas and electricity. To-day a wide vestibule coach is worth in the neighborhood of $10,000.—F. W. Brazier, presidential address, M. C. B. Association.

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In discussing the power required of a locomotive to move itself, figures were quoted from tests on the London & Northwestern Railway before the Institution of Mechanical Engineers, showing that in one case at 60 miles an hour a locomotive used 444 out of a total of 1 170 h.p. to move itself. This large proportion of unproductive work suggests a very important line of investigation in connection with high-speed locomotives.

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A TRAVELING RAILROAD MACHINE SHOP.—An 80,000-lb. box car has been fitted up as a traveling machine shop by the Morgan Construction Company, Worcester, Mass. According to the *American Machinist*, it is equipped with a 20-in. Reed lathe, an 18-in. Stockbridge shaper, a Norton emery grinder, a forge, anvil, bench and vise, and also a number of small tools. The car is used in connection with the erection of large buildings and such plants as rolling mills. An 8 h.p. gasoline engine furnishes the power.

## THE POSSIBILITIES OF THE RAILWAY MOTIVE POWER OFFICER.

BY A RETIRED SUPERINTENDENT OF MOTIVE POWER.

What a flood of reflections are aroused by the above subject! The discussion of the possibilities and the probable final outcome as to operative and financial success for any official who may have selected the mechanical department as the field for the exercise of his talents is a fruitful theme at least for present consideration, even if the possibilities have only been realized to a very limited extent in the past. To present the subject in a clear and logical manner with only so much partisanship as may justly be allowed to one who has at heart the success of mechanical work, considered from a railway standpoint, and the well-being of those who are engaged therein—even this is a difficult task. To present the subject in most forceful terms and by really strong arguments would seem to call for a presentation from a somewhat too personal standpoint. For one to say "out loud" that the American mechanical worker has had a ban put upon him, either intentionally or on account of existing conditions, would possibly seem to some to suggest a defense of this proposition, involving a statement of personal experiences and pros and cons which in the end might engender hard feelings detrimental to the good results hoped for. Hence it is with some degree of circumspection that one would approach the subject, not on account of any innate fear as to the justice of the cause advocated, but on account of the uncertainty as to the effect on the minds of some who might unjustly suppose that the writer had in view some particular officials, unique and strange, whose peculiarities he was endeavoring to hold up to the light of day. Yet *personal* experience is to some extent the basis of knowledge and belief, and I trust that mine may justify any facts set forth without malice.

I violate no confidence when I say that among those with whom I have talked on the subject there has been a very strong evidence of discontent with railway mechanical work, both as to the relation of the mechanical to the other departments and as to the probable outcome of a life spent in that department. I would also further state that I have met almost as many higher officials who were dissatisfied with the results obtained by their mechanical departments, so the discontent is not all on one side. To bring about better results would certainly be a commendable object, and a free discussion of the subject will not hurt either the public or the mechanical department, though it might affect in the end other departments in so far as the offices, which on some lines have always been held by men from other branches of the service, might be thrown open to the deserving men who have had their training in the mechanical department.

In this busy world, with its struggle for existence, distinction and future monetary welfare, as a rule, neither man, union nor corporation voluntarily gives up any advantage which may be enjoyed over a competitor. It therefore cannot be expected that any man connected with other than the mechanical department, who is not obliged to do so, is going to give up any advantage which, given up, might mean the advancement of a competitor to his own detriment. Hence a recognition of the mechanical worker as a candidate for still higher positions must come from those who have gotten past the point in their official career where they need fear mechanical department competition. I make no charge of any incompetency or unfitness on the one hand, against those who have had the advantage thus far, nor do I argue any special fitness for the man with mechanical training over his successful rival in the other departments. I would only ask consideration for the mechanical department unfortunate in so far as his ability gives evidence of his desirability as a candidate for something better, instead of the almost general custom of the past, which has kept a man in the mechanical department so long as he remained in service, and practically never has admitted that a mechanical department man could be good enough for anything else. While I am free to admit that long service in the mechanical department may put a man beyond the time when his mind is alert and grasping as to new ideas and present progress, yet it would seem that at a certain time in his career he might be as desirable as some whom custom has marked for preference.

A certain amount of mechanical training ought not to be adverse to the highest success in railway work; yet a search of the records of the higher officials reveals the fact that there are about thirty men who have enjoyed the title of master mechanic and succeeded in getting beyond the mechanical department confines. A further search will show that there are about eleven hundred positions on American railroads which might be opened to the deserving mechanical man. I say these positions might be opened on the ground that those fortunates who have escaped are holding such positions as I have included at present—successfully, for aught I know to the contrary. There are at least 750 men who hold the title of master mechanic, or better, in railway mechanical work at present. From these figures I think one can obtain some idea without further comment as to the probabilities of the mechanical officer obtaining further recognition as things are at present constituted.

It may not be amiss to add that one railway system forms quite a prominent exception to the prevailing custom of promotion, and a considerable percentage of those who have been favored are from this one system. I do not believe there is any ground save appearance for the old story of the sectionman who desired to get his boy Johnny into the mechanical department in preference to the other departments, giving as a reason for his preference, "Johnny is not very bright."

The general success of the mechanical department is intimately connected with the welfare of the railroad, and a failure of this department from any cause whatsoever is generally keenly felt. Theories are much easier to change than material facts. The mechanical department deals with material matters, and the failure of the machine to do the work required is often so much more apparent than any other that the proper handling of the machine and the failure to anticipate mechanical department needs are quite often lost sight of in the haste of those affected to "get under cover."

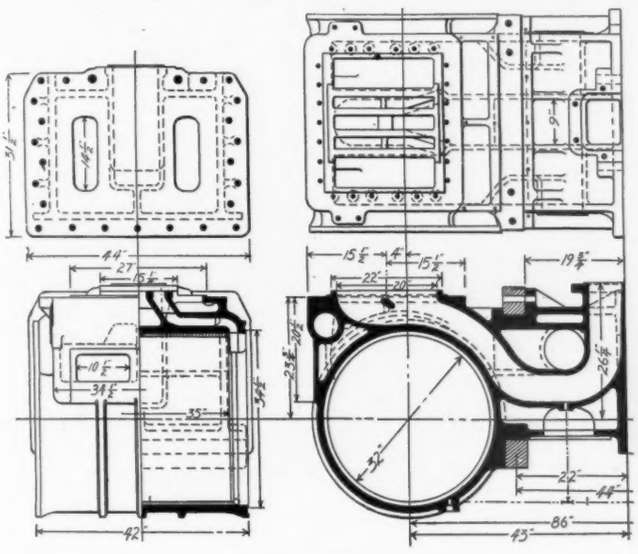
A little more mechanical knowledge in the operating department would aid the mechanical department and a great many failures which do not primarily belong to the mechanical department, but which in the end lodge at its feet, due to the final result being looked at and the causes which led up to it being overlooked, would be thoroughly understood and much unnecessary friction avoided. A little more interest of the mechanical department taken in the operating problems will tend to do away with the ancient worship of the machine and the consequent forgetting of what the machine was primarily designed for. This will help the other departments. It is complained that mechanical men cannot put themselves in the place of the other departments. Possibly a lack of opportunity to look the other side of the fence has made them self-centered.

It would seem that there is going to be as great a demand for mechanical talent in the future as in the past. The development of large railway shops and modern methods will certainly call for the best that is to be had and the best will be none too good to meet the problems before them. I think I do not misjudge the present conditions when I say that there are none too many good mechanical men in the field at present. It would seem to me that some outlet near the top of the mechanical department system would have to be provided in order to get the needed new blood in at the bottom and thus avoid stagnation at the top. Helping the mechanical department and at the same time getting mechanical knowledge more generally throughout the working system of the railway are not the only points to be gained by a more general recognition of the mechanical department in the higher field of railway work. Greater rewards will naturally

call more men into the mechanical field, which is to be desired.

At present it is quite difficult in some cases for railroads to fill their special apprentice lists with satisfactory men, the time is so long and the compensation so slight at starting that many do not wish or cannot afford to bind themselves for a period of three years for what the mechanical department of an average railroad has to offer as compared with other lines of business. It would seem to a certain extent, as far as final results are concerned, time wasted for a man to undertake to fit himself for a railway mechanical position and to go through the necessary apprenticeship lasting until he is in some cases from 28 to 30 years of age before he holds anything but student positions. The same amount of energy and endurance applied to other than the railway mechanical field ought to bring greater returns. Something should be done to make railway mechanical work a more attractive proposition, either by a more general recognition of the mechanical department in selecting the higher operating officials or by raising the compensation of the mechanical officer to a figure which is commensurate with that paid by manufacturing enterprises of the same magnitude. The latter plan would contemplate the mechanical man staying in that department, which he would be willing to do if the dignity of the department were increased by proper compensation. I would think the former method would be conducive to better results.

Only by some such changes as above suggested will mechanical *possibilities* become mechanical *probabilities*. Many will agree that the field for railway mechanical work is not an attractive one at present.



MALLET COMPOUND LOCOMOTIVE—LOW PRESSURE CYLINDER.

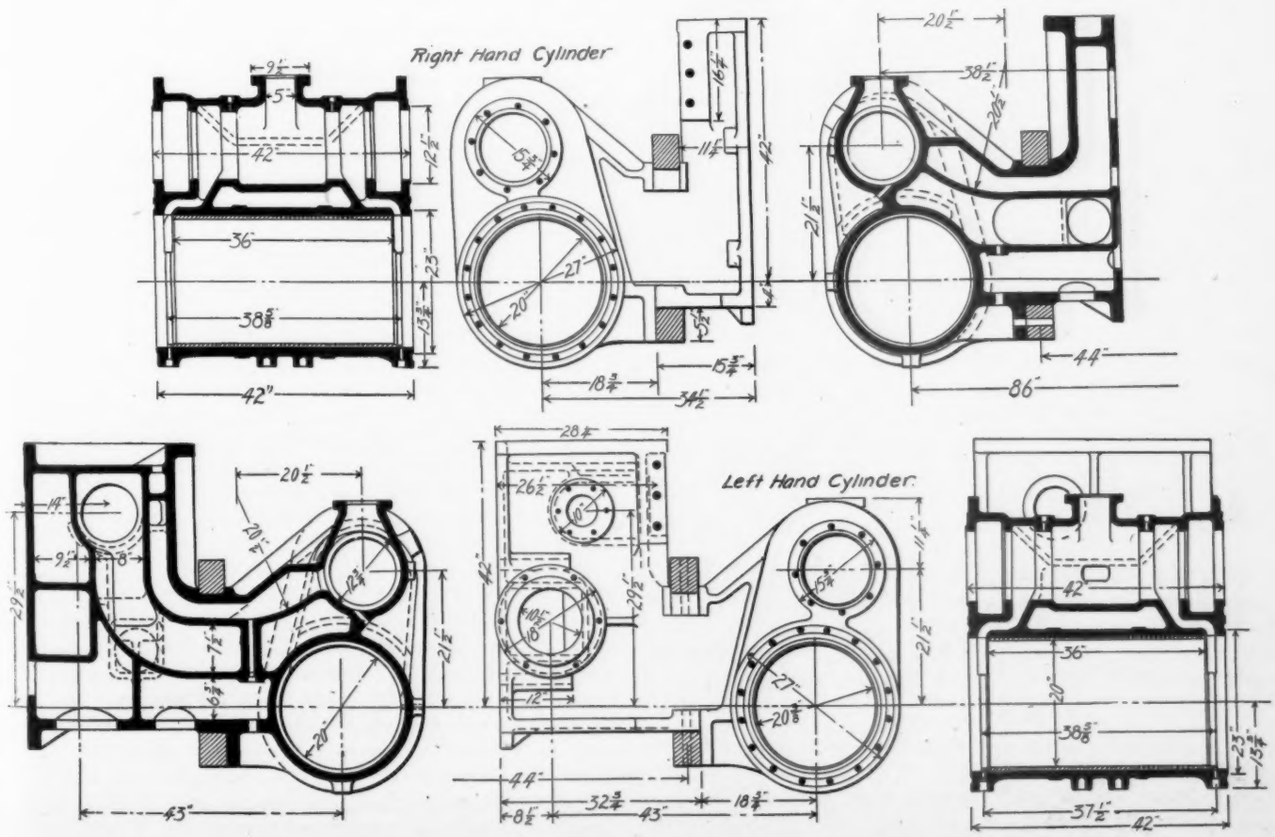
## MALLET COMPOUND LOCOMOTIVE—0-6-6-0 TYPE.

BALTIMORE & OHIO RAILROAD.

ADDITIONAL DETAILS.

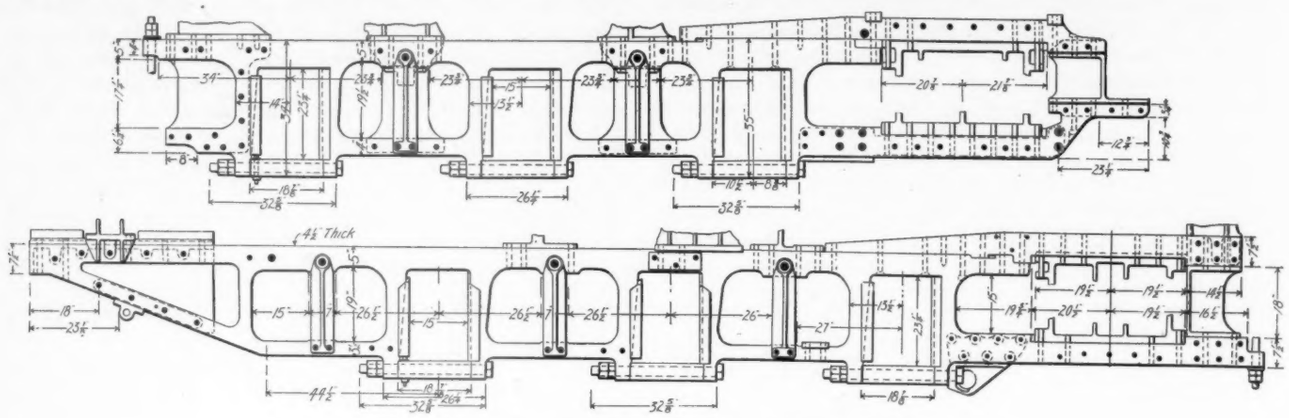
Supplementing the description of this locomotive (AMERICAN ENGINEER, current volume, pages 167, 237 and 262) some of the most important details are now presented. These include the cylinders, frames and the long receiver pipe connecting the high and low pressure cylinders. While the power of this locomotive is very great, the individual parts, except the boiler, are not excessively large. This is indicated in the drawings of the cylinders and frames. This fact is one of the important features of this form of locomotive development for large and powerful units. It involves the principle of dividing the work among a large number of parts as distinguished from obtaining the increased capacity by a mere increase in size of the parts. If no improvement in economical operation was to be expected this principle of dividing the work would constitute a sufficient advantage to justify the Mallet type for large freight locomotives.

Several problems were encountered in the cylinder and re-

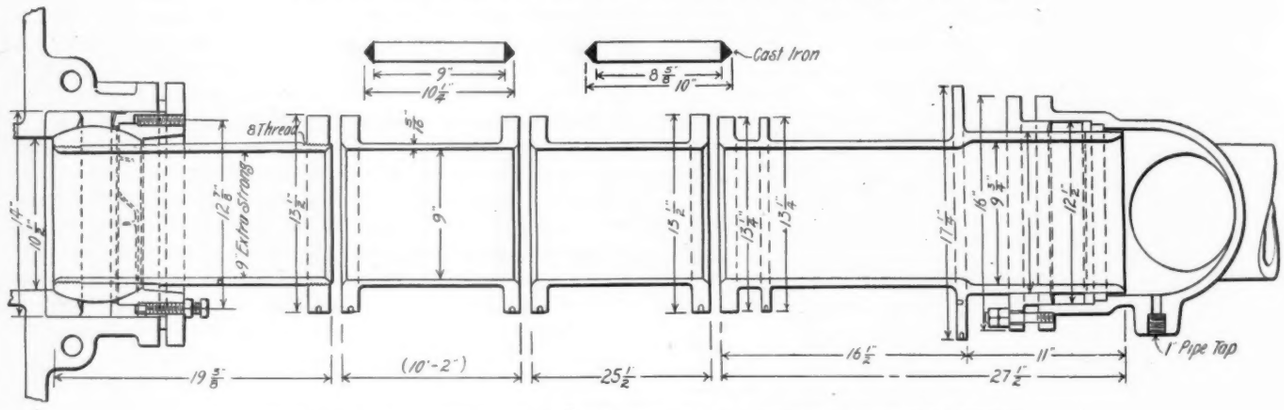



MALLET COMPOUND LOCOMOTIVE—HIGH PRESSURE CYLINDERS, RIGHT AND LEFT HAND.

ceiver construction. Because of the necessity for providing a tight joint for the receiver pipe, the high pressure cylinders do not part midway between the frames, and are therefore not alike, the pipe joint being at one side of the centre. Bushings are provided for all cylinders. The receiver pipe is of steel, lap welded, with welded flanges. It has a ball joint, with cast iron rings at the back and a slip joint at the front end. Thus far these joints have remained perfectly tight.



MALLET COMPOUND LOCOMOTIVE—DETAIL OF MAIN FRAMES, FRONT AND BACK.




MALLET COMPOUND LOCOMOTIVE—RECEIVER PIPE, WITH SLIP AND BALL JOINTS.

## PERSONALS.

Mr. Frank N. Hibbits has resigned as consulting mechanical engineer of the Southern Railway to accept the position of mechanical superintendent of the New York, New Haven & Hartford Railroad, with headquarters at New Haven, Conn., to succeed Mr. John Henney, superintendent of motive power, resigned.

Mr. F. T. Hyndman has been appointed superintendent of motive power of the Buffalo, Rochester & Pittsburg Railroad, to succeed Mr. Charles E. Turner, who has resigned. Mr. Hyndman's headquarters will be at Du Bois, Pa.

Mr. John Henney, who has for many years held the position of superintendent of motive power of the New York, New Haven & Hartford Railroad, has resigned to take a well-earned rest, and he will probably take an extended trip to Europe.

Mr. Charles E. Turner has resigned as superintendent of motive power of the Buffalo, Rochester & Pittsburg Railroad. He has held that position for nearly 10 years, and during this time has brought the condition of the motive power and car equipment of this road up to the highest standard.

Mr. C. W. Osborn has been appointed foreman of shops of the Chicago & North Western Railway at Fond du Lac, Wis. Mr. Osborn began service with this road as a special apprentice, and his advance to this position is a result of ability combined with hard and faithful work.

Mr. R. F. Hoffman has been appointed assistant to the general superintendent of motive power of the Frisco system, with headquarters at St. Louis, Mo.

Mr. B. D. Lockwood has been appointed mechanical engineer of the Cleveland, Cincinnati, Chicago & St. Louis Railway, to succeed Mr. R. L. Ettinger.

Mr. J. H. Wynne has been appointed mechanical engineer of the Illinois Central Railroad to succeed Mr. C. A. Strom.

Mr. R. L. Ettinger has resigned as mechanical engineer of the Cleveland, Cincinnati, Chicago & St. Louis, to succeed Mr. F. N. Hibbits as consulting mechanical engineer of the Southern Railway, with headquarters in Washington.

Mr. Theo. N. Ely, chief of motive power of the Pennsylvania Railroad, has been honored by receiving from Hamilton College the degree of Doctor of Science. He was graduated from Rensselaer Polytechnic Institute with the degree of Civil Engineer, and was honored by Yale University with the degree of Master of Arts.

MR. GEORGE WESTINGHOUSE—"He has made a chain of world-encircling industries. Presumably he is proud of it, and he has a right to be. No other man has done this thing. It is an achievement imperial in its scope. It may be asked from what special achievement he derives most satisfaction. It is a natural question, and one night he made a remark which may be taken as the answer to it: 'If some day they say of me that with the air brake I contributed something to civilization, something to the safety of human life, it will be sufficient.'"—*Arthur Warren, in the New York Times.*

## SHOP EQUIPMENT.

BY WILLIAM S. COZAD, NORFOLK & WESTERN RAILWAY.

In a certain shop repairing several hundred engines per year it requires four men an hour each to get a pair of driving-wheels into the lathe, which is no fault of the men, but a lack of proper facilities for doing the work. This shop has a very large air compressor, but no air jack is provided to handle these wheels.

In another small shop wheels are rolled in on the main track, picked up by an air hoist, dropped into the machine and chucked in twenty-five minutes. The machine man and one helper do the work after the wheels are rolled into the shop.

A certain new car shop, just completed, has a transfer table operated by an air engine. This apparatus has eccentrics, cranks, handles, link motion, and about everything else except the necessary machinery to stop it at the precise point. It contains a storage drum which must be charged at the end of each transfer every time the table is used. This is a great improvement over the old method of handling the table by hand, but an electric motor would cut the present time in two. No time would be lost in charging the tank nor in stopping at the right place, but the table would always be ready to put in motion.

A very large number of the turntables used at present are still operated by hand, and no one not in actual touch with the work can form much idea how expensive and unsatisfactory this method is. At the Norfolk & Western shops in Roanoke, Va., which handle 70 to 80 engines per month, the turntable was, until a year ago, operated by hand. This required three to four laborers to turn a heavy engine, and in winter we would often have to call out as many as a dozen men. This not only cost the company the time of the men directly engaged, but usually caused delay to a large force in the shop. The table is now equipped with an electric motor and will transfer an engine in two minutes.

Another shop, not far away, handles a large number of engines on an old-fashioned transfer table operated by gear wheels and cranks. Suppose that four men can operate this table under all conditions. To get an engine out, transfer and "pinch" it in on another pit or onto the main track will require at least one hour, or a total of four hours for the men operating the table. Every man working on that engine will lose, as a rule, the time which it takes to transfer it. At least two mechanics and two helpers work on the same engine at the same time. Now figure transfer men at 15 cents per hour, machinists at 30 cents, machinist helpers at 20 cents, and the total cost per transfer is $1.60. If the shop overhauls 30 engines per month each engine must be handled at least twice, making a total of $96 per month for transfers, or $1,152 per year, not counting a great deal of other work handled in this way.

Shop machinery in many of the old shops is not located with reference to the work to be done. I visited a shop lately where crossheads are fitted in one end of the shop and pistons in the other, with the result that crossheads go first to one place to be taken apart, then to another to have the piston rods fitted, and to another to have wrist pins tried, and still to another point to have shoe bolts fitted, then back to be put together. Rods are overhauled in one end of the machine shop, and about as far away from the erecting shop as it is possible to get, and rod brasses are bored and shaped in the other end, which requires unnecessary handling of material, a great loss of time by both mechanics and foremen, and usually a general misunderstanding among all concerned. Driving box brasses are turned at one end of the shop, shaped at another point, put into boxes in another place and bored at another point, and for want of a press, helpers drive out all old brasses with a sledge.

In the blacksmith department of a certain shop two forges were occupied in dressing and tempering tools for machine shop use. One smith was forging heavy tools. He put one tool into the fire, got it hot, then ran 20 yards to the nearest hammer to forge it. Occasionally some one a little closer would step in ahead of him, he would lose the heat, and the same performance would be gone over again. The helper was also in evidence, standing idle both at the fire and at the hammer. In this shop there is no doubt tool work enough to keep one hammer constantly employed, which, in connection with good heating facilities, would effect a saving sufficient to pay for the hammer in a year or less.

The same department of another shop capable of turning out 10 engines per week has but one hammer. Some roundhouse work, road work and extra car work must be done in addition to the 10 engines. Another hammer in this shop would pay for itself in six months. A Bradley cushion hammer, or one of similar construction, has a capacity equal to at least four forges on properly classified work, but it is seldom that one is seen in a railroad shop.

Many of the old shops are still lifting engines off their wheels with hydraulic jacks. This requires three or four men from two or three hours to a day or two, depending entirely on the condition of the jacks. Usually when a heavy engine is about half way up, one or more of the jacks fail and repairs must be made. Four pneumatic telescope jacks would accomplish this same work in about 30 minutes with proper air pressure. Engines lifted off the wheels with jacks are often left high in the air, thus requiring men to work on them with the bottom of the frame as high as their heads. This destroys about one-half the capacity of the workman. If he works on a scaffold one-half his energy will be required to maintain his position while the other half is applied to his work.

In a shop employing two or three hundred men I found no tool room. There was no space for a tool room inside the shop. At another place I found what was called a tool room in which were a few old, antiquated machines used to keep up the tools, but entirely unfit for the work assigned to them. The men were very intelligent and courteous and apologized for the condition by saying it was the best they were able to get.

I saw recently an old truck wheel lathe with a bed twice as long and large as necessary to support its other parts in use in a shop maintaining the repairs on 700 engines. The capacity of that machine was one pair of wheels per day. Much of this work, therefore, had to be done on driving-wheel lathes, where, on account of difficulty in chucking, two or three pairs of wheels were a day's work. A modern lathe would turn out seven pairs of wheels per day. Suppose five pairs the average per day. On the old machine this work would require five days at a cost of $10 for labor, allowing 20 cents per hour. The same work on a new machine would require one day, a net saving to the company of $8 per day, besides the use of the machine for the extra four days. A new machine here would pay for itself in 12 months and also pay the operator.

Knuckle joint pins cost for forging about 20 cents and for turning on an ordinary lathe 35 cents each, a total of 55 cents. On the modern turret lathe these pins can be made from the rough bar for 16 cents each, excluding fitting. Wrist pins forged and turned complete in the old way cost about 75 cents each; on a modern turret lathe they would cost about 20 cents each, fitting excluded. Knuckle joint pins, lift shaft and all similar bushings cost 15 to 20 cents each when forged in the blacksmith shop, yet on a modern lathe they can be cut from steel tubing at a cost of about one cent each and bored and turned for much less than if forged. These differences will hold good on all work for which these lathes are adapted, and any repair shop having work of this kind in sufficient quantity to keep one or more of these machines occupied will find they will pay for themselves every 12 months in the saving effected.

Every railroad shop has a labor or roustabout gang, and in this department there is usually the greatest leak compared to the amount of money invested to be found in any part of the plant. For instance, in a shop on one of the largest roads in the country many hundred pairs of car wheels are loaded every year. A car is placed at the end of a long straight track and two timbers are laid, one end on the car and the other on the ground at end of track from which wheels are to be taken. Then with two men on the car and two or three at points along the line, a pair of wheels are started and delivered from man to man until they are landed on the car at a speed of about 20

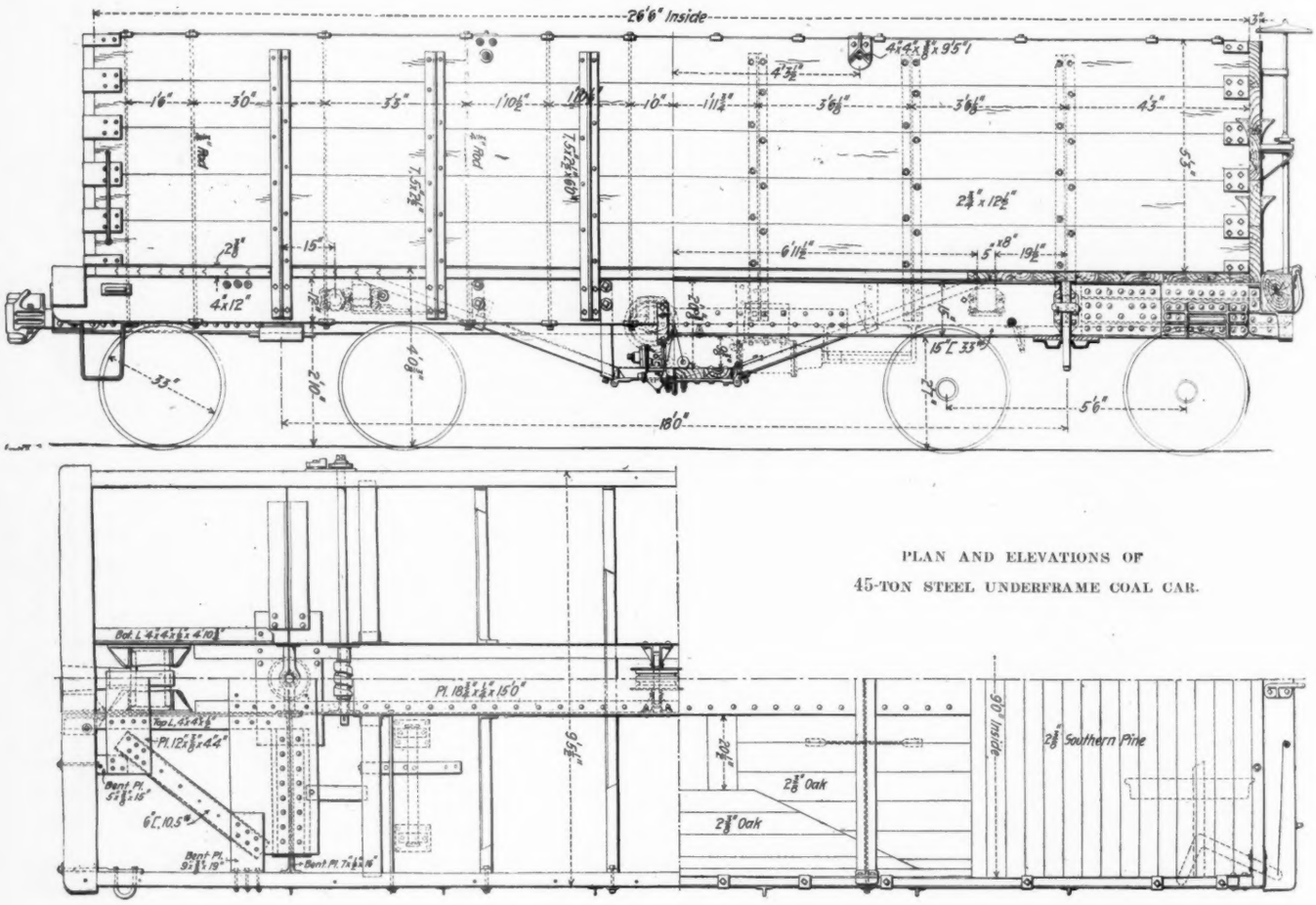
miles per hour. This requires from two or three hours to half a day, depending on the time required to place and remove this apparatus and the number of wheels that get away. A pneumatic hoist placed in the center of the track would lift the wheels and place them on two short pieces of rail, whence they could be rolled onto the car in the shortest possible time. This would require two men 30 or 40 minutes to load a car at a cost depending on the day rate of the men involved.

I was connected with a plant some time ago where it cost 11 cents each to unload pressed steel car bolsters and about four cents more to reload and get them into the erecting shop, total 15 cents. This company used several hundred of these bolsters every year, and a few dollars invested in crane facilities would have reduced the cost of handling to about two cents each; the crane would also have been very useful for other work.

A great many blacksmith shops are still heading bolts on old, antiquated machinery in connection with coke furnaces (and I suppose a coke furnace is good enough for that kind of a machine) at a cost of from 25 cents to 40 cents per 100 for ¾ to 1-in. bolts, while a few other shops have put in up-to-date machines and oil furnaces and reduced the cost of this work to about $1 per 1,000 bolts.

until this is done it must be remembered that where little is given little should be required. It is always possible to improve shop methods, but there is a point beyond which we can not go, and if few of the shops at present pay a dividend on the money invested it is not particularly on account of poor methods, but surely on account of the large number of old machines in use.

Let the superintendent of motive power who may read this article ask for a statement of the number of lathes, planers, drill presses, boring mills, etc., that have been in constant use in his shops for the last 15 or 20 years and note the result. I saw such a list recently which had been compiled by the foreman of a large shop and over 60 per cent. of the machinery in that shop had been in constant use 15 to 20 years, some of it much longer. If these machines were not affected by wear they would still be run at a loss because of the great improvement in construction of shop machinery in the past




PLAN AND ELEVATIONS OF
45-TON STEEL UNDERFRAME COAL CAR.

CONCLUSIONS.

1. The average railroad shop is at the rear of the procession so far as modern facilities for turning out work are concerned.

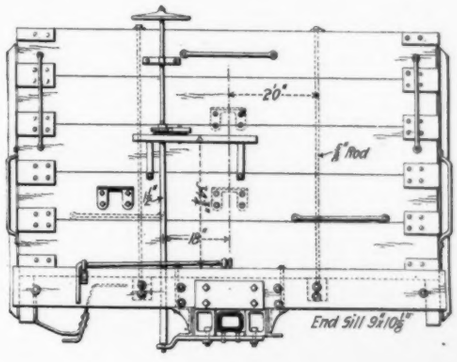
2. If motive power is in demand and it is necessary to reduce the time of engines in the shop to the minimum and utilize shop space to the best advantage, such machinery must be put into the shop as will perform the work in a reasonable length of time.

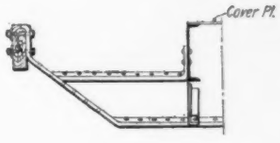
3. It is sheer nonsense to expect a foreman to turn out any definite amount of work on worn-out machinery; to utilize high-speed steel to best advantage on machines that have been in use 25 or 30 years.

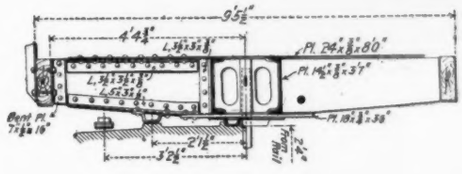
4. A repair shop can not be put on a commercial basis unless modern machinery and modern methods are used, and five or six years. We formerly used chilled cast iron cutting tools for many classes of work, but since the self-hardening steels came out we do not use these tools, but we do try to use the same old machines. There is nothing that seems to get quite so close to the heart of a railroad company as an old machine. When one of these relics become so worn that it is entirely unfit for service in one shop, it is repaired and sent to some outlying point to take up valuable room for another 10 or 20 years. Another important point to be considered is the marked effect such tools have on the workmen in the shop. Men make shop conditions, and in time these same conditions make other men to a greater or less degree; and as long as a lot of old, antiquated machinery is kept running in the shop and other conditions correspond, we shall not get the benefit of the best efforts of the men employed. As a general proposition men do not rise above their surroundings. Like begets like; and as the conditions and facilities for doing work are improved, the interest of the men in the general welfare of the company will grow accordingly.

## 45-TON STEEL UNDERFRAME COAL CAR.

Through the courtesy of Mr. George I. King, drawings and a photograph of a 45 ton coal car with structural steel underframe have been received. This design was prepared for the Bulah Coal Company, and the cars were built by the Middletown Car Works. The car is similar to the Class G N cars of the Pennsylvania Railroad. It is mounted on Pennsylvania Railroad standard 50-ton arch bar trucks and is fitted with the new centre construction designed by Mr. King. Its light weight is 35,700 lbs. with these heavy trucks, which were selected in order to avoid excessive wheel failures, which have become troublesome in connection with large capacity cars. At the same time the trucks will be invaluable for cars of larger capacity should they be needed for this purpose. For the 4 by 10 in. side sills of the Pennsylvania cars, Mr. King substituted



4 by 12 in. sills, and for the pressed steel stakes rolled steel tees.

Mr. King has developed the end construction of the steel underframes, which is indicated in the drawings. The centre sills are of 15-in. channels and terminate 2 ft. beyond the bolsters. From these points riveted extensions are provided, to continue the centre sills, carry the draft gear and support the end sills, which are of wood. The connections to the end sills are made with large steel castings, giving ample bearing surface and including the coupler carry iron. This construction facilitates repairs in case of damage to the end of the sills without taking down the entire sill. A cover plate is placed over the centre sills between the bolsters, and the bolsters are of diaphragm form, riveted to the center sills. The drawing gives the sizes of the angles and thicknesses of plate used. At the corners of the car are substantial channel braces extending between the top cover plate of the bolsters, enlarged for this purpose, and a 2-in. plate riveted across the ends of the extensions of the centre sills. This plate is 44 ins. long. The form of the hopper and its construction are shown in the drawing.

## LOCOMOTIVE TESTING PLANT AT ST. LOUIS.

### PENNSYLVANIA RAILROAD TESTING PLANT.

The Pennsylvania Railroad has issued Bulletin No. 3 concerning the tests to be made on the locomotive testing plant at St. Louis, from which the following is reproduced:

DESCRIPTION, DIMENSIONS AND PROPORTIONS.

DRIVING WHEELS.

1. Number of pairs
2. Approximate diameter, inches
3. Measured circumference, feet, Right No. 1
4. " " " " " 2
5. " " " " " 3
6. " " " " " 4
7. " " " " " 5
8. " " " Left " 1
9. " " " " " 2
10. " " " " " 3
11. " " " " " 4
12. " " " " " 5
13. Average " "

ENGINE TRUCK WHEELS.

14. Number
15. Diameter, inches

TRAILING WHEELS.

16. Diameter, inches

WHEEL BASE.

17. Driving wheel, base, in feet
18. Total wheel base, in feet
19. Gage of wheels, in inches

WEIGHT OF ENGINE, POUNDS.

(With water at second gage cock and normal fire.)

20. On truck
21. On first drivers
22. On second drivers
23. On third drivers
24. On fourth drivers
25. On fifth drivers
26. On trailers
27. Total
28. Total on drivers

45-TON STEEL UNDERFRAME COAL CAR.

CYLINDERS.

29. High pressure, number
30. Low pressure, number
31. Arrangement
32. Diameter, inches, high pressure, right
33. Diameter, inches, high pressure, left
34. Diameter, inches, low pressure, right
35. Diameter, inches, low pressure, left

STROKE OF PISTON, FEET.

36. High pressure, right
37. High pressure, left
38. Low pressure, right
39. Low pressure, left

CLEARANCE, PER CENT. OF PISTON DISPLACEMENT.

40. High pressure, right, head end
41. High pressure, right, crank end
42. High pressure, left, head end
43. High pressure, left, crank end
44. Low pressure, right, head end
45. Low pressure, right, crank end
46. Low pressure, left, head end
47. Low pressure, left, crank end

RECEIVER, CUBIC FEET.

48. Volume, right side
49. Volume, left side

STEAM PORTS, INCHES.

(For piston valves the length equals the circumference of inside of bushing, minus the sum of the widths of bridges.)

50. High pressure admission, right, head end, length
51. High pressure admission, right, head end, width
52. High pressure admission, right, crank end, length
53. High pressure admission, right, crank end, width
54. High pressure admission, left, head end, length
55. High pressure admission, left, head end, width
56. High pressure admission, left, crank end, length
57. High pressure admission, left, crank end, width
58. Low pressure admission, right, head end, width
59. Low pressure admission, right, head end, width
60. Low pressure admission, right, crank end, length
61. Low pressure admission, right, crank end, width
62. Low pressure admission, left, head end, length
63. Low pressure admission, left, head end, width
64. Low pressure admission, left, crank end, length
65. Low pressure admission, left, crank end, width
66. High pressure exhaust, right, length

67. High pressure exhaust, right, width.....
68. High pressure exhaust, left, length.....
69. High pressure exhaust, left, width.....
70. Low pressure exhaust, right, length.....
71. Low pressure exhaust, right, width.....
72. Low pressure exhaust, left, length.....
73. Low pressure exhaust, left, width.....

PISTON RODS, DIAMETER, INCHES.

74. High pressure, right.....
75. High pressure, left.....
76. Low pressure, right.....
77. Low pressure, left.....

TAIL RODS, DIAMETER, INCHES.

78. High pressure, right.....
79. High pressure, left.....
80. Low pressure, right.....
81. Low pressure, left.....

VALVES.

82. Type .....
83. Design .....
84. Balanced area in per cent of total.....
85. Type of link motion.....

GREATEST VALVE TRAVEL, INCHES.

86. High pressure, right.....
87. High pressure, left.....
88. Low pressure, right.....
89. Low pressure, left.....

OUTSIDE LAP OF VALVE, INCHES.

90. High pressure, right, head end.....
91. High pressure, right, crank end.....
92. High pressure, left, head end.....
93. High pressure, left, crank end.....
94. Low pressure, right, head end.....
95. Low pressure, right, crank end.....
96. Low pressure, left, head end.....
97. Low pressure, left, crank end.....

INSIDE LAP OF VALVE, INCHES.

98. High pressure, right, head end.....
99. High pressure, right, crank end.....
100. High pressure, left, head end.....
101. High pressure, left, crank end.....
102. Low pressure, right, head end.....
103. Low pressure, right, crank end.....
104. Low pressure, left, head end.....
105. Low pressure, left, crank end.....

MISCELLANEOUS.

106. Cylinder lagging, material.....
107. Cylinder jacket, material.....

BOILER.

113. Type .....
114. Outside diameter, first ring, inches.....

TUBES.

115. Number .....
116. Outside diameter, inches.....
117. Thickness, inches.....
118. Length between tube sheets, inches.....
119. Total fire area, square feet.....
120. Serve tubes, number of ribs.....
121. Serve tubes, square inches of inside surface in one inch of length..

SUPERHEATER.

125. Number of tubes.....
126. Outside diameter, inches.....
127. Thickness, inches.....
128. Length of tubes, inches.....

FIREBOX, INSIDE.

132. Length .....inches.....
133. Width .....inches.....
134. Depth, front end.....inches.....
135. Depth, back end.....inches.....
136. Volume .....cubic feet.....

FIRE DOORS.

141. Number .....
142. Area, square feet.....

GRATES.

144. Style .....
145. Total area, square feet.....
146. Total area, dead grates, square feet.....
147. Width of air spaces, inches.....

AIR INLETS.

148. Through firebox sides.....Square feet
149. Through grates.....Square feet
150. Through fire doors.....Square feet
151. Total air inlets, No. 148, No. 149 and No. 150.....Square feet
152. Ratio air inlets (No. 149) to grate area (No. 145).....
153. Ratio air inlets (No. 151) to grate area (No. 145).....

HEATING SURFACE, SQUARE FEET.

154. Of the tubes, water side.....
155. Of the tubes, fire side.....
156. Of the firebox, fire side.....
157. Of the superheater, fire side.....
158. Total, based on inside of firebox and inside of tubes.....
159. Total, based on inside of firebox and outside of tubes.....

BOILER VOLUMES.
(With water surface at level of second gage cock.)

160. Water space, cubic feet.....
161. Steam space, cubic feet.....

EXHAUST NOZZLE.

162. Double or single.....
163. Dimensions of right side, inches.....
164. Dimensions of left side, inches.....
165. Area of right side, square inches.....
166. Area of left side, square inches.....
167. Total area, left side.....

REVERSE LEVER.

168. High pressure cylinder, notches forward of center.....
169. Low pressure cylinder, notches forward of center.....

RATIOS.

171. Heating surface (No. 158) to grate area (No. 145).....
172. Fire area through tubes (No. 119) to grate area (No. 145).....
173. Firebox heating surface (No. 156) to grate area (No. 145).....
174. Tube surface (No. 155) to firebox heating surface (No. 156).....
175. Firebox volume (No. 136) to grate area (No. 145).....

CONSTANTS.

179. For dynamometer horse-power (power developed when the speed is one r.p.m. and the pull is one pound).....
For indicated horse-power (power developed at one r.p.m. and one pound m.e.p.).....
180. High pressure cylinder, right, head end.....
181. High pressure cylinder, right, crank end.....
182. High pressure cylinder, left, head end.....
183. High pressure cylinder, left, crank end.....
184. Low pressure cylinder, right, head end.....
185. Low pressure cylinder, left, crank end.....
186. Low pressure cylinder, left, head end.....
187. Low pressure cylinder, left, crank end.....

FOR PISTON DISPLACEMENT, CUBIC FEET.

188. High pressure cylinder, right, head end.....
189. High pressure cylinder, right, crank end.....
190. High pressure cylinder, left, head end.....
191. High pressure cylinder, left, crank end.....
192. Low pressure cylinder, right, head end.....
193. Low pressure cylinder right, crank end.....
194. Low pressure cylinder, left, head end.....
195. Low pressure cylinder, left, crank end.....

The numbered blank spaces are provided so that information concerning unusual features of the locomotive under test may be inserted. The dimensions and constants will be given for each locomotive tested, the observed data and calculated results for each test. There will be from 14 to 20 tests on each locomotive.

The method for obtaining the dimensions and data given is in most cases self-evident; but that these may be clearly understood, and also to show the precautions taken to insure accuracy, the following are deemed sufficiently important to require special mention:

DESCRIPTION, DIMENSIONS AND PROPORTIONS.

Items Nos. 3 to 13. The circumference of the driving wheels will be measured with a flexible steel tape, divided in feet and hundredths of a foot. The circumference will be taken at the point where the driver would rest on the rail. The gage of track being 4 ft. 8½ ins. and the width of the rail head being 2¼ ins., the distance between the circumferences to be measured is 4 ft. 10¾ ins.

Items Nos. 20 to 28. As there is no scale at St. Louis with sufficient capacity to weigh many of the locomotives which are to be tested, the locomotives will be weighed at the most convenient point by a member of the testing force, although in some cases it may be necessary to take the builders' weights of the engine in working order.

Items Nos. 32 to 35. The diameters of cylinders will be taken with an inside micrometer caliper, at the head end, crank end and middle of the bore of the cylinder. These three locations in the cylinder will be measured with the calipers in a vertical position, and also in a horizontal position; the diameter given being an average of the six measurements obtained in this manner.

Items Nos. 36 to 39. The locomotive being set on one of its dead centres, the distance from some convenient point on the guides or cylinder to some point horizontally in line on the crosshead or piston rod will be measured. A similar measurement will then be taken between the same two points with the locomotive on the other dead centre. The difference between these two measurements in feet will give the stroke.

Items Nos. 40 to 47. The volume of clearance will be obtained by placing the locomotive on the dead center and filling the clearance space with water from a vessel holding a known weight of water. The water remaining in the vessel will be weighed and the rate of leakage from the clearance space observed. From these data the volume of the clearance space can be readily calculated, and 100 times this volume, divided by the volume of piston displacement, will be the result desired. As a check, the clearances will be calculated from measured dimensions and working drawings, but preference will be given to the results obtained by the use of water.

With piston valve engines it will be necessary to place the valve so that it will block the steam port; a tell-tale hole being provided to allow the escape of air and to show the height of the water. By removing a cylinder cock, and using a hand pump, the water may be forced in from below, and the amount ascertained.

Items Nos. 48 to 49. The receiver volumes will be ascertained if practicable in the same manner as the volume of clearances.

Items Nos. 50 to 73. The length of the steam and exhaust ports given will not be the actual length, but will be such a dimension that, multiplied by the actual width, will give the actual area of the port. The measurements are given in this way to allow for the rounded corners usually found in cylinder ports.

Items Nos. 74 to 81. The piston rods and tail rods will be measured at several points by a micrometer caliper. The diameter given for each rod will be the average of all measurements.

Item No. 84. The balanced area of the valve will be the product of the dimensions to inside edges of balance strips or rings; the total area that of the entire face of valve.

Items Nos. 86 to 89. The greatest valve travel will be obtained with the reverse lever in full gear forward, by scribing the valve rod and measuring with a tram.

Items Nos. 90 to 105. The outside and inside laps will be calculated from measurements of valve and valve seat taken while hot, and their relative positions at centre of valve travel.

As a set of working drawings will be furnished, the chief purpose of these measurements will be to check the drawings.

Item No. 114. The outside diameter of the first or smallest ring of the boiler will be calculated from the circumference as measured with a flexible steel tape.

Items Nos. 116 and 117. As the thickness and outside diameter of tubes vary considerably after they have been in service, for nominal diameter and specified thickness will be taken.

Item No. 118. The length of tubes, between tube sheets, will be obtained by measuring the length over beads of a number of tubes well distributed and deducting the thickness of tube sheets and beads.

Item No. 119. The total fire area of tubes will be obtained by multiplying the area of cross section of inside of tube by the number of tubes.

Item No. 121. As a factor in obtaining the surface contour of the Serve tubes, a strip of adhesive tape will be pressed into the form of the ribs of the tube or a cast of the same. The length of this tape in inches will equal the square inches of surface in 1 in. of length.

Items Nos. 126 and 127. The dimensions of superheater tubes will be found in the same way as already described for boiler tubes.

Items Nos. 132 and 133. The length of the firebox will be measured at the level of the bottom of fire door, and parallel to line of rail, the width being the horizontal distance between side sheets at mid-length.

Items Nos. 134 and 135. The depth of firebox will be the measured distance (perpendicular to the rail) from grate surface to crown sheet at front and at back of firebox.

Item No. 136. The volume of firebox will be calculated from dimensions of the firebox above the surface of the grates, and checked from the drawings.

Item No. 147. The width of the air spaces in grates will be, with bar grates, the actual width of the openings; with finger grates, the maximum opening.

Item No. 149. The area of the air inlets through the grates will be calculated from drawings known to correctly show the grates.

Item No. 150. The air inlet area through fire doors will be the area of dampers or holes in fire door, when dampers are open as far as possible.

Item No. 154. The heating surface of the water side of the tubes will be obtained by multiplying the circumference of the outside of tube, in feet, by the length between tube sheets, in feet, and by the number of tubes.

Item No. 155. The heating surface of the fire side of the tube is to be obtained in a similar manner to Item No. 154, except that the internal diameter of the tube will be used. In the case of Serve tubes the length over the ribs (No. 121) divided by 12 is the circumference in feet.

Item No. 156. The heating surface of the firebox is the area calculated from measurements of the firebox sheets, above the level of the grates, less the total fire area of the tubes (No. 119), the area of fire doors (No. 142), and the area of air inlets through sides of firebox (No. 148).

Item No. 157. In the heating surface of superheater will be included any headers, etc., which may form a part of the true superheating surface.

Items Nos. 158 and 159. The heating surface of the superheater, for a locomotive so equipped, is included in these items; using the fire sides of tubes and headers. The heating surface, based on the fire side, will be used in all calculations in these tests.

*(To be continued.)*

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## THE APPLICATION OF INDIVIDUAL MOTOR DRIVES TO OLD MACHINE TOOLS.

BY R. V. WRIGHT.

McKEES ROCKS SHOPS.—PITTSBURG & LAKE ERIE RAILROAD.

### XIII.

MISCELLANEOUS TOOLS.

This article presents some interesting but very simple motor applications which were made to a large punch and shear, a small punch and a slab milling machine.

Fig. 60 shows a motor application made to an old Hilles & Jones No. 3 punch and shears, which will punch a 1⅜-in. hole in 1-in. plate and will shear 1-in plate. The motor is, in this case, supported by a simple cast-iron bracket, which was designed to correspond to the contour of the frame and is firmly bolted to the frame of the tool. The speed cone which was used with the belt drive was removed and replaced by the larger Morse silent-chain sprocket. The motor is a Crocker-Wheeler 10I.-L.S.-C.C.M., which is capable of developing 10 h.p. at 240 volts. It is operated at a constant speed, and the tool runs at a rate of 25½ strokes per minute. The starting box is located on the panel board, which is placed close to the base of the tool just below the motor.

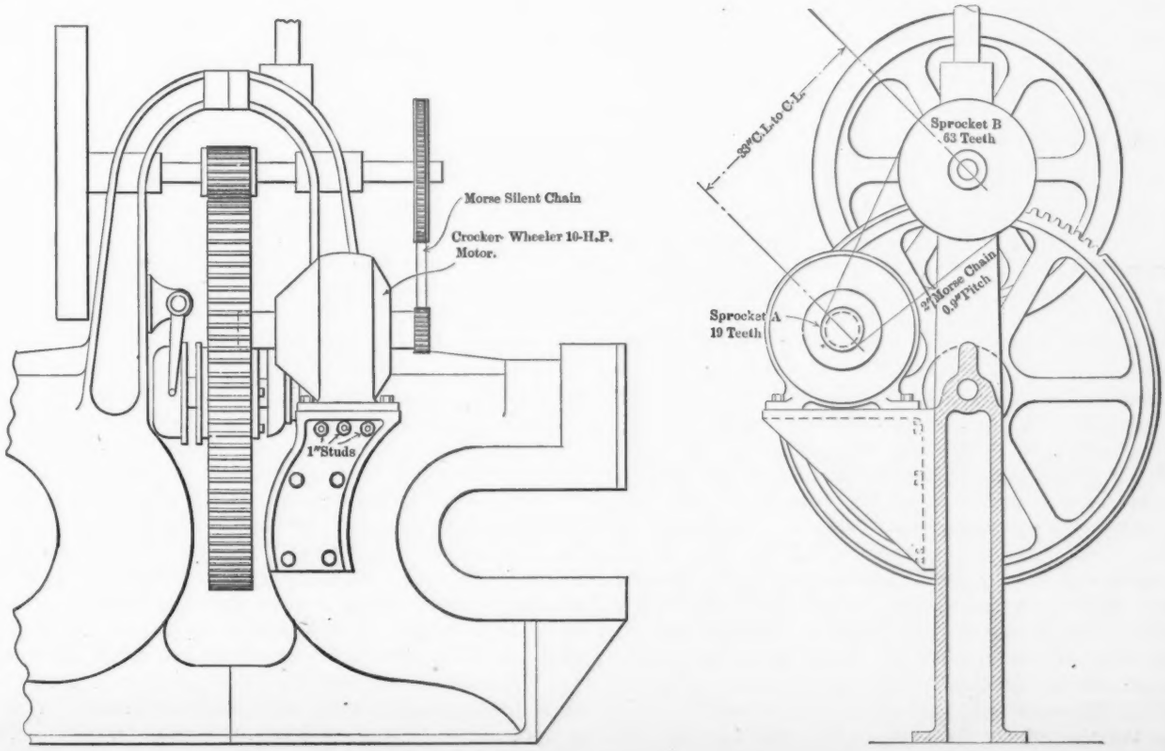



FIG. 60.—APPLICATION OF MOTOR DRIVE TO HILLES & JONES PUNCH AND SHEARS.

Fig. 61 illustrates the application of a motor to a small punch made by the Excelsior Machine and Cleveland Punch and Shear Company, which will punch a 13-16-in. hole in ⅜-in. plate. The motor is supported by two brackets of 1⅛-in. x 4-in. wrought-iron bar; one end of each bracket is fastened to the floor by ⅝-in. lag screws, and the other end is bolted to the frame of the tool as shown. The belt speed cone was replaced by the large Morse silent-chain sprocket. The motor is a 5 h.p. type I.-L.S.-C.C.M. machine, which develops 5 h.p. at 240 volts. The tool runs at a speed of 39 strokes per minute. The starter is on the panel board, which is placed near the motor and close to the tool.

An application of a motor to a Sellers slab milling machine is shown in Fig. 62. With the belt drive a cone on shaft A was driven from a countershaft. Pulley C was merely an idler, and run loose on shaft B. The feeds were operated by a pulley, which was keyed to shaft B where the Morse silent-chain sprocket now is, and which was driven from a countershaft.

When the motor was applied the speed cone was removed from shaft A, and pulley C was keyed to shaft B. The pulley which operated the feed shaft B was replaced by the Morse silent-chain sprocket D and was driven from the motor by the Morse silent-chain as shown. The motor is a Crocker-Wheeler M.S.-C.M., which will develop 6½ h.p. at 240 volts. It is operated by a 40-M.F.21 controller, and the maximum speed of the tool is 75 revolutions per minute. The controller is bolted to the side of the housing on the side opposite the motor.

## IMPRESSIONS OF FOREIGN RAILROAD PRACTICE.

EDITORIAL CORRESPONDENCE.

(*Continued from page* 265.)

Crank axles are very common here because the prevailing types of locomotives for years have employed inside connected cylinders. The older and smaller engines do not work their axles severely enough to cause any anxiety because of cracks, but the heavier and more recent locomotives require very careful watching. Crank axles run from 200,000 to 300,000 miles without trouble, and then they are usually removed because of cracks which generally develop in the region of the junction of the crank pins and webs. When the rods are down the cracks are easily discovered and are closely watched for developments. Circular cracks around the crank pins or the body of the axle are not allowed to grow, and the axles are scrapped, but the other, or corner, cracks are sometimes allowed to advance as far as 1½ in. from the edge, providing the advance is not at a greater rate than about one-sixteenth inch per month. Twice this rate of advance is considered excessive and dangerous. These observations cover in a general way the practice of a number of roads. No one here seems to be in the least degree anxious about crank axles, but it is evident that they are most carefully inspected and conscientiously cared for. The older and smaller types of engines almost invariably have solid axles, with the cranks cut out of solid forged steel, but the advances in speed and

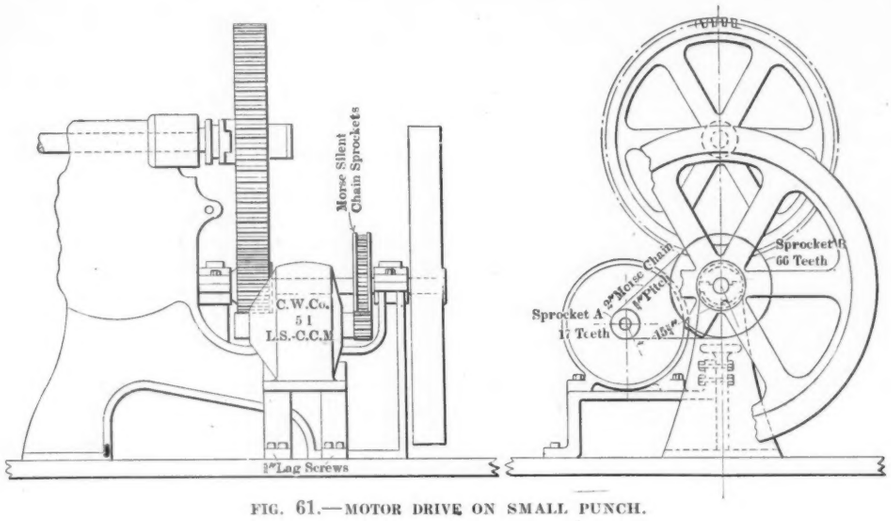



FIG. 61.—MOTOR DRIVE ON SMALL PUNCH.

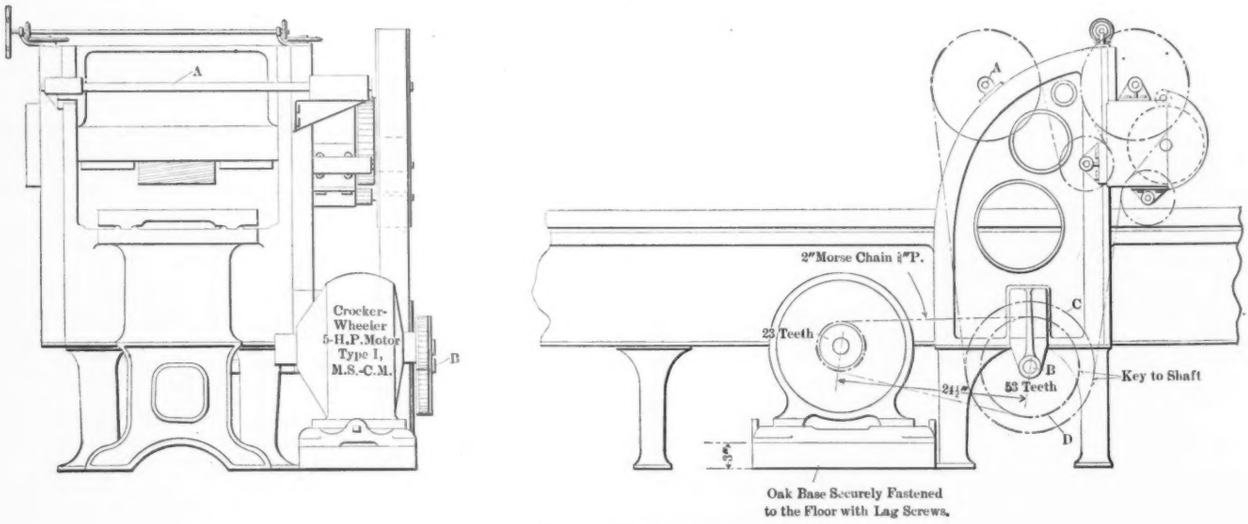



FIG. 62.—MOTOR DRIVE APPLIED TO SELLERS SLAB MILLER.

power have compelled the construction of built up cranks. The limits to the solid crank axle have been reached. In the recent types of fast passenger engines built up construction is used. The webs and crank pins are pressed on, and this method is not only cheaper but it does not torture the material as does the bending in forged cranks. It also avoids the expensive cutting away of material of solid cranks. The built up axles, furthermore, provide some elasticity at the joints, which appears to relieve the structure from the local bending and tends to prevent localized flexures and consequent cracking. Some of the roads make their crank webs, pins and bodies of axles of different steels, having a touch of highly scientific metallurgy, which is guarded as a secret. There seems to be little in this, however. This subject is important to Americans just now because, whether they like them or not, crank axles are sure to be used in future American locomotive practice. It will be necessary for us to go into greater refinements in design of locomotives, and no one can study the locomotive in England, France and Germany without seeing the unquestionable advantages of the application to American practice of the principles which accompany the latest developments involving crank axles. We must get more power from the weights we use, and to do this we must inaugurate scientific designing. That this can not be avoided in justice to the locomotive, to the American traveling public and the owners of our railroads is one of the apparently important conclusions in this tour of study. This will be mentioned again. It is made prominent just at this point because so much centers in the crank axle.

In the frame construction of English engines an important feature of bracing stands out prominently. The deep and thin plate frames, usually ⅞ or 1 in. thick, tend to cover up the valve motion and render the vital parts of the running gear inaccessible. This does not appear attractive in any way. With the deep plate frame, however, very great vertical strength is secured, and the frames as a whole are not rigid against side stresses. It is customary to brace these frames admirably, and in exactly the way in which American frames are weakest. At the cylinders a deep brace is secured by the cylinder bolts. The motion plate which crosses between the frames and holds up the rear ends of the guides, is generally of cast steel, and is a girder as deep as the frames. A third deep brace or cast steel diaphragm crosses the frames back of the leading driving axle of a 2—6—0 engine, and under the front end of the firebox is another one, not quite as deep. These braces tie the frames together across the engine, but they do much more than that. Because of their depth they act as the diagonal braces of bridge trusses and prevent twisting of the frames. This is believed to be an important matter, and is just now receiving careful attention in the new freight engines of the Lake Shore, which have been illustrated in this journal. A rather close questioning of English officials did not discover any serious difficulties with frames on the larger types of engines which have gone into service during the past five or six years. We might advantageously apply this method of preventing twisting, due to heavy side stresses in entering and leaving curves, against which our frames are not in the least protected.

Trains in England are always light, relatively, to ours. A 500-ton passenger train is unknown, and a 1,000-ton freight train is unheard of on most roads. In fact, but one road was found having any trains of this weight. As a rule the track and bridges are not sufficient for engines capable of handling 1,000-ton freight trains. Freight service, therefore, except as to speed, offers little of interest. It is not so, however, with passenger service here, with 300 to 375 ton trains, running on schedules of 50 miles and over per hour. These trains carry many passengers, and more than ours of equal weight. This fact is commented upon elsewhere in this review. Foreign railroads are not "blessed" with passenger agents and the Pullman Company, with their influences in the direction of great weights of passenger equipments. Sleeping cars here are not in extensive use, and are not required on most runs. Those which are used are much lighter per passenger than ours. As a general statement, it is safe to say that the number of passengers carried by an American train of 600 tons would travel in an English train of about 200 tons. Of course this bears an important relation to the weight and capacity of locomotives. The delicate screw thread couplings of English "carriages" tell a story with respect to the locomotives, but these engines do wonderful work considering their weight and size.

The severest service in Great Britain is the London-Scotch traffic on the east and west coasts. On both sides of the island material advances were made in the capacity of locomotives about eight years ago. This was immediately met by an increase in the weights of cars and trains, and a recent advance in the locomotive has been again accompanied by increasing the requirements.

The severest service in Great Britain is on the Caledonian Railway. The train leaving Glasgow for Carlisle at 2 p. m. weighs 360 tons, back of the tender, not including passengers and baggage, and the corresponding train from Carlisle to Glasgow usually weighs 300 tons, the speeds ranging about 56 miles per hour. With lighter trains, weighing 200 tons behind the tender, this road makes runs averaging 59 miles per hour from Sterling to Perth, 33 miles, and from Forbar to Perth, 32 miles. This is done by engines weighing 116,908 lbs. The grades on this section are 2 miles of 59 ft. per mile; 2 miles of 65 ft. per mile, and 6 miles of 70 ft. An example of good work by a light engine is a recent performance of a 110,660-lb. engine in starting a train from Stonehaven to Dubton, with 6½ miles of an average grade of 170, this distance being made in 11½ minutes, with a minimum speed of 35 miles per hour, the train weighing 198 tons. This grade begins at the Stonehaven station. I could not secure figures for coal consumption for individual runs, except in terms of rough weights, which are not satisfactory. The firemen, however, are not overworked, though they must use great skill and must co-operate very carefully with the engineers in order to keep up steam pressures. The reversing quadrants on these engines are very finely divided, and the engines are carefully and scientifically handled. In the United States the advent of a new locomotive of increased power sometimes has the effect of discouraging the men who still run the lighter engines, and they fall back in their efforts to make time with the smaller engines. It is not so in Great Britain. I never have seen small and light engines worked as skillfully as these are. The men are expected to get the utmost out of the small and old engines. They certainly do it.

In England as in the United States the combination of technical education and practical experience is sought in providing succession in the office of locomotive superintendents, and it is becoming increasingly difficult for a man to rise from the ranks. This appears to many people as an unimportant matter, but it surely is important. In England in the early development of railroads, locomotives were always designed and built by locomotive building concerns. The responsibilities of locomotive superintendents began in operation and repairs. Occasionally a locomotive engineer was promoted to have charge of shops, and afterward advanced to the head of the department. This developed a type of strong, practical men, now represented by a few veterans whose standing as railroad officials and locomotive experts is very high. Naturally they became educated, though they are not necessarily classed as engineers. Some of these men stand for the most progressive methods in Great Britain to-day, although it can not be said that they are the only progressive ones.

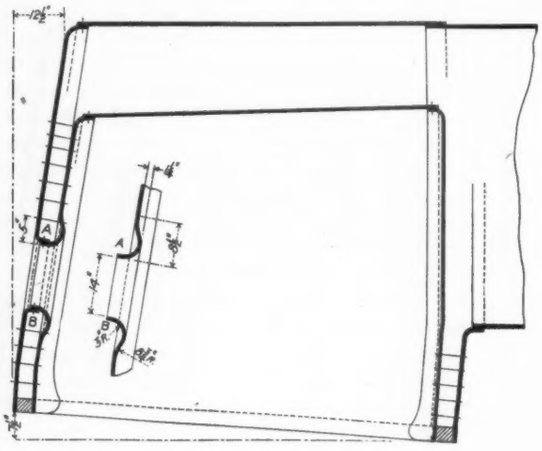
About 35 years ago the roads began to build their own locomotives, and most of them supply their own wants to-day, both as to design and construction. This brought the drawing office into prominence, which is now a very important branch of the service. This change opened the way for the educated engineer. Occasionally one of these was appointed to take general charge of the department, and "practical" men were depended upon to look after operation. Now it is quite difficult, if not impossible, for the practical men to rise to the

top, not for lack of ability, but of opportunity to show what they can do. Of course a single instance does not prove anything, but it is worth noting that in one case two roads were found running in conjunction and hauling through traffic. The road under the educated engineer has continued the use of light engines, which have been habitually double-headed, while the same trains were hauled over the connecting line by single engines of much greater power, which were designed under the direction of a "practical" man. The latter operated at an advantage because of the thorough understanding of the operating side of the department by the chief. The writer is confirmed in the opinion that it is very desirable to establish a plan of promotion with respect to the chief motive power officer, which will accomplish two things: First, develop the talent of the rank and file by opening the way for promotion of all alike who possess ability. Second, to establish a method whereby educated men will prepare for their responsibilities slowly and thoroughly. G. M. B.

*(To be Continued.)*

## IMPROVED FIRE DOOR FLANGE.

Very good reports are received with respect to this fire-door flange on locomotives on the Chicago & Northwestern Railway. Door joints, with abrupt flanges, have always been troublesome, because the flanges are alternately heated very hot when the door is closed and cooled when it is open. Usual construction produces stiffness in the sheets and a rigidity around the door which causes the expansion and contraction to localize and develop cracks which are difficult to repair. The joint illustrated has been developed and patented by Mr. M. O'Connor, foreman boilermaker of the Chicago & Northwestern, at Missouri Valley, Ia. He states that it is being applied to all locomotives requiring heavy boiler work at that point and that of twenty-eight locomotives fitted with it in the past three years, no failures have been found. This form of door flange provides a rounded surface of the sheets, and a particularly full curve of the inside sheet. This gives the sheet an opportunity to bend without cracking, and it also increases the space for water circulation around the door opening. This construction avoids sharp bends, prevents lodgment of scale and mud, and it costs no more than other forms of door flanging.




IMPROVED FIRE DOOR FLANGE.

BARDONS & OLIVER TURRET LATHE—Bardons & Oliver of Cleveland, O., have just shipped to the Canadian Pacific Railway at Montreal a 5-in. turret lathe with an automatic chuck and wire feed, whose net weight is over 20,000 lbs. It will turn 42 ins. in length and will make a 4¾-in. crosshead pin from bar steel at the rate of 3 per hour. It is the heaviest machine of this type that has ever been built.

## THE OPPORTUNITY OF THE ENGINEER.

The official estimates of the Government make the present population of the United States 80,000,000. Reasoning from the past it seems probable that twenty-five years from now our population will be 125,000,000. That is, by the time that the young engineers now starting their life work have reached a ripe and active middle age the population of the United States will be as great as the present population of the United Kingdom, the German Empire and two-thirds of France added together. It will be a homogeneous population, of high average education, and averaging higher in courage, enterprise and self-reliance than the people of any other great country, for reasons which we need not now go into. That population will be planted in a temperate climate, in a country of unequalled natural resources, intersected by great natural waterways, covered with a network of railroads, and with vast coast lines on two great oceans. The wealth, the power, the physical and intellectual influence of such a nation may be guessed at; they cannot be measured.

Such is the inheritance of the American youth who stands to-day in the gateway of life. To the young engineer all this has an especial meaning. Heretofore we have been relatively an agricultural people. Soon we shall be relatively a manufacturing people. Doubtless we shall long continue to be the greatest food producing nation; but we shall come to be also the greatest manufacturing nation. The opportunities we offered to courage and enterprise plus highly trained intelligence. That means that the great prizes of the next quarter of a century will be for the engineer. But if he will grasp them he must not only be an engineer; he must be a man.—*H. G. Prout in Electric Club Journal.*

## RAILROAD PROGRESS AS SHOWN BY INTERSTATE COMMERCE COMMISSION STATISTICS.

The total single track railway mileage in the United States on June 30, 1903, was 207,977.22 miles, having increased 5,505.37 miles in the year ending on that date. This increase exceeds that of any previous year since 1890.

On June 30, 1903, there were in the service of the railways 43,871 locomotives, the increase being 2,646. As classified, these locomotives were: Passenger, 10,570; freight, 25,444; switching, 7,058. There were also 799 not assigned to any class.

The total number of cars of all classes was 1,753,389, this total having increased 113,204 during the year. The assignment of this rolling stock was, to the passenger service, 38,140 cars; to the freight service, 1,653,782 cars; the remaining 61,467 cars being those employed directly by the railways in their own service. Cars used by the railways that were owned by private companies and firms are not included in this statement. The average number of locomotives per 1,000 miles of line was 214, showing an increase of 8. The average number of cars per 1,000 miles of line was 8,540, showing an increase of 345 as compared with the previous year. The number of passenger-miles per passenger locomotive was 1,978,786, showing an increase of 70,476 miles. The number of ton-miles per freight locomotive was 6,807,981, showing an increase of 141,482 miles as compared with June 30, 1902.

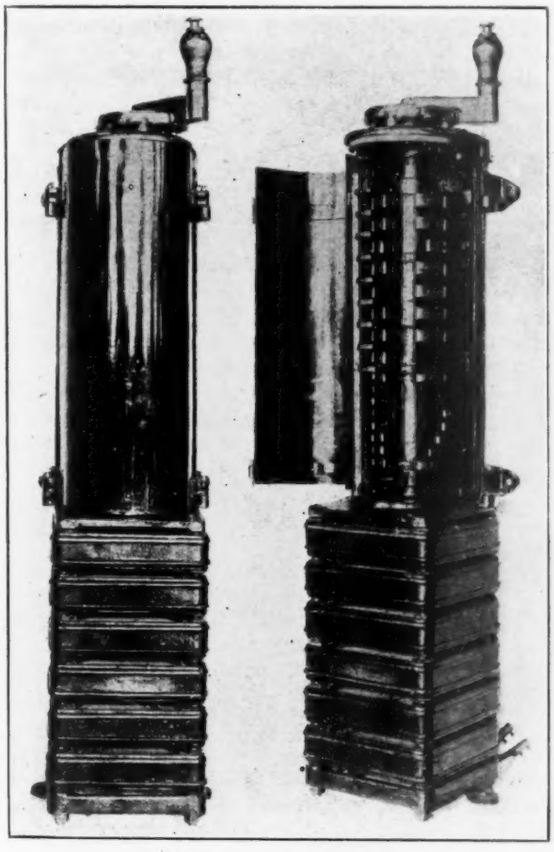
Practically all locomotives and cars in passenger service had train brakes, and of the 10,570 locomotives in that service, 10,110 were fitted with automatic couplers. Most of the freight locomotives had train brakes and 98 per cent. of them automatic couplers. Of 1,653,782 cars in freight service on June 30, 1903, 1,352,123 had train brakes and 1,623,330 automatic couplers.

The number of persons on the pay rolls of the railways in the United States, as returned for June 30, 1903, was 1,312,537, or 639 per 100 miles of line. These figures, when compared with corresponding ones for the year 1902, show an increase of 123,222 in the number of employes, or 45 per 100 miles of line. The classification of employes includes, enginemen, 52,993; firemen, 56,041; conductors, 39,741, and other trainmen, 104,885. There were 49,961 switch tenders, crossing tenders and watchmen. With regard to the four general divisions of railway employment it appears that general administration required the services of 45,222 employes; maintenance of way and structures, 433,648 employes; maintenance of equipment, 253,889 employes; and conducting transportation, 576,881 employes.

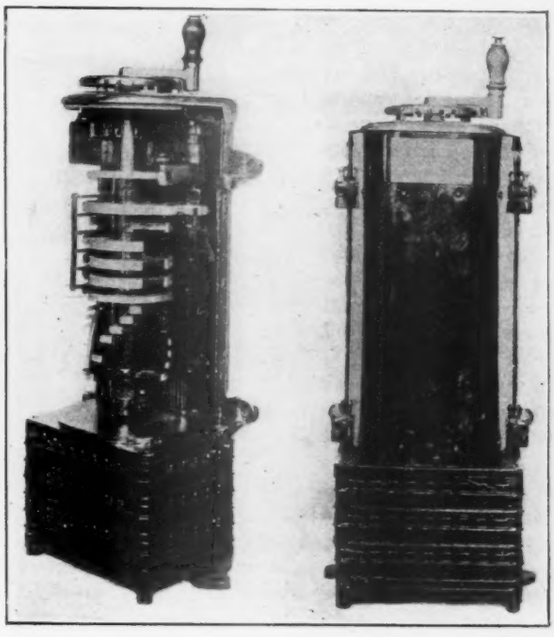
## REGULATING AND REVERSING CONTROLLERS FOR MACHINE-TOOL MOTOR DRIVING.

A new type of controller, particularly adapted for use with independently-driven machine tools, has recently been designed by the Westinghouse Electric & Manufacturing Company, manufactured as types V and W, which cover a wide range of sizes and capacities to fulfill all the requirements of service.

The type V controllers are used upon 2-wire single voltage circuits, eight forward speeds and four reverse speeds being obtained by resistance in the shunt field circuit of the motor. In the type W, which is designed for use in connection with 3-wire 2-voltage circuits, the speed variations are obtained by means of the two voltages, as well as the shunt field-resistance, provision being made for 6 forward speeds on the lower and 9 on the higher voltage, and 6 reverse speeds on the lower voltage. Experience has proven that this number of speed variations is the best possible for general use, and affords all the differences in speed which are required in service.



TYPE V CONTROLLER.



TYPE W CONTROLLER.

CONTROLLERS FOR MACHINE TOOLS.

The type V controllers are ordinarily adopted when a speed variation of 2 to 1 is required, and the type W for variations of 4 to 1, although other variations may be obtained as desired, each installation being separately considered and the controller used which is best adapted to the motor with which it is to be used. The successive intermediate speeds are arranged in practically geometrical progression, but extra leads are provided by the use of which the owner may make such changes as he desires.

In general structure, these controllers are based upon the most modern and improved types of controller design, insuring reliability and long life, regardless of hard usage. The drum is made of metal and secured to an insulated shaft. The contact strips and the fingers are of hard rolled copper, and the fingers are provided with lock nuts and adjusting screws. All parts are liberally proportioned and are made easy of access. The cover can easily be removed by withdrawing the pins which hold it in place, and access to the leads is quickly obtained by removing the strips screwed to the back of the controller.

Another important feature which assures the adaptability of these controllers to various conditions is the fact that the handle and ratchet are so designed that they may be removed from the controller and placed at any point which is convenient, permitting connection to the controller by means of bevel gears and shafting. This not only adapts the apparatus for distant control, but it enables the operator to use the same handle, ratchet and indicator dial which are furnished with the controller; this saves the expense of making a new handle and ratchet, as is necessary in some cases.

The notches in the ratchet are positive, and the design is such that as each step is reached a key drops into a notch and stops the handle, holding it firmly in place until released by a pressure upon the thumb stop in the end of the handle. The operator is thus able to watch his work uninterruptedly while applying power or changing the speed—a fact of distinct advantage. The handle and ratchet are simple in construction and each step is plainly indicated and numbered.

In the type V controller the starting resistance is inserted when the first contact is made, being cut out when the handle is moved to the second position. In the type W a cam lifts from the contact the finger whose function is to cut out the starting resistance, and thus leaves the resistance in circuit when starting or when changing to a higher or a lower voltage. By means of a dash pot, the return of the finger is delayed for a predetermined interval of time, the speed of the return being regulated by means of a screw; the checking medium is a non-freezing liquid, greatly superior to air as a means of even and close regulation and not affected by atmospheric conditions. If desired, the dash pot can be removed without disturbing any other portions of the controller.

Arc shields are placed between all contacts which carry the main current, and in addition all sizes above 10 h.p. have a powerful magnetic blow-out coil.

In capacities to and including 10 h.p. the resistance, which is of the imbedded type, is regularly mounted directly beneath the controller, as shown in the accompanying illustrations. In larger sizes it is mounted separately. The leads are conveniently located and have screw connectors. These controllers are designed in every particular to give superior service under even the least favorable conditions.

## A TEST OF A MOTOR DRIVEN PLANER.

BY J. C. STEEN.

Following closely after the series of articles recently published in these columns upon the motor driving of planers, it is believed that an account of an interesting test upon a motor-driven planer recently made will be appreciated. The planer is one built by the Pond Machine Tool Company, 66 ins. in width and having a platen 12 ft. long. The motor which is used to drive this machine is one built by the Northern Electric Company, of Madison, Wis. It is a 15 h.p. compound-wound motor running at 400 r.p.m. with the normal line voltage of 220. An extended armature shaft carries the driving pulleys direct, and upon the extended shaft is also carried a heavy balance wheel, the utility of which will be seen upon examination of the following diagram and data given.

These data were obtained by means of a recording ammeter, the accompanying diagrams being traced directly from the record strip. The use of this instrument enables a graphical showing to be made of the power consumed during any period of time, or cycle of operations, of the machine being tested. Its use also makes possible the calculation of the actual total power consumed for a given time.

The work done upon the planer during the test required a platen traverse of about 8 ft. The two surfaces cut were about 26½ ins. long each, with a space between, so that the cut was not continuous. Both tool heads were used, each one carrying a cut of ⅝ in. in depth with a feed of ⅛ in. The material was of cast iron, of medium hardness. While the cuts taken are not nearly up to the capacity of the machine, the work represents average practice fairly well.

The results of the test are given as follows, the voltage being 215 as an average throughout the test:

Power required to drive the motor, driving shaft, the pulleys on the machine, and the platen in forward direction, no cut being taken; average gross power of.....10.3 h.p.
Power required for return of platen, including reverse.....16.9 h.p.
Power required at time of heaviest cut (maximum).....14.4 h.p.
Power required at moment of reverse from return to cut (max.).16.3 h.p.
Power required at moment of reverse from cut to return (max.).22.4 h.p.
Power required as average throughout entire cycle of platen movement .....13.6 h.p.
The time required for one cycle of platen movement .48 min. or 29.0 secs.
The time required for cutting movement of platen.. .34 min. or 20.5 secs.
The time required for return movement of platen.. .14 min. or 8.5 secs.

From the above it will be seen that the ratio between the time of reverse and cutting movement is 1 to 2.43.

By the application of a Warner cut-meter to the moving platen it was found that the cutting speed was at the rate of 25 ft. per minute, with a return speed of 75 ft. per minute, a ratio of 1 to 3. The difference between these two ratios may be taken to represent the time loss at reversals. The action of the motor was all that could be desired.

It will be seen that the power required to reverse the direction of platen movement from cut to return was only 22.4 h.p., an increase of but 55 per cent. over the power necessary at maximum cut, and an increase of 64 per cent. over the average amount required during the whole cycle of movement. This maximum power is much less than might be expected from a machine of this size, and the very favorable result shown is undoubtedly very largely due to the balance wheel on the motor shaft. It will be understood of course that a balance wheel requires some expenditure of power to keep it in motion, but as this is a relatively small amount it is more than compensated for by the advantages obtained by its use. Another result of the balance wheel action will be seen upon reference to the diagram. The depth of the cut was quite uniform throughout its length, yet there is no sudden rise in the power line at the point where cut begins, the rise being gradual up to the point of maximum power. This feature will be noticed at the beginning point of each cut.

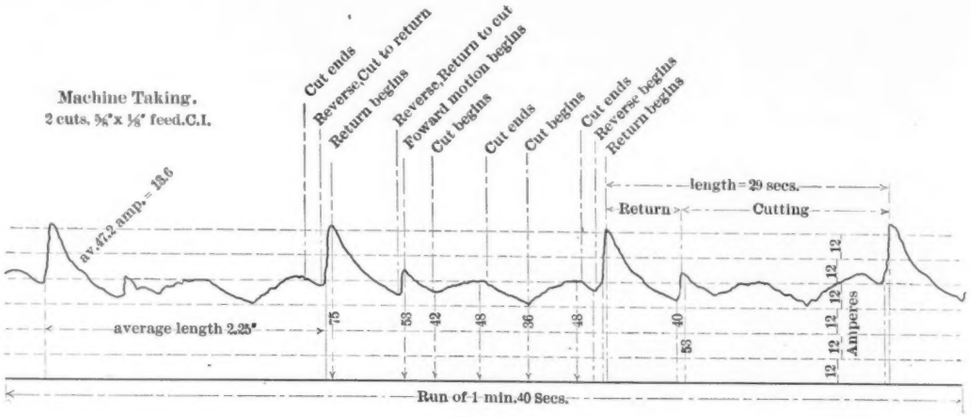



FIG. 1.

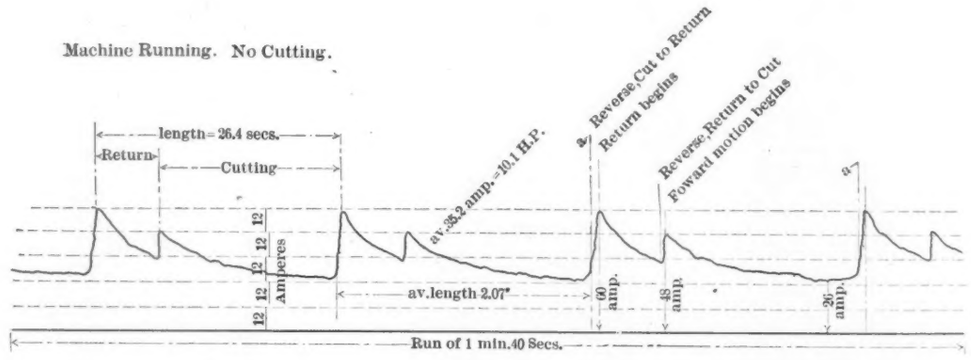



FIG. 2.

From the data given above, certain information is obtainable which can be used under similar conditions, as, for instance, taking the maximum power rate of 14.4 h.p. for cutting and the quantity rate of metal removed at 46.8 cu. ins. if cutting was continuous, we have as a result the following:

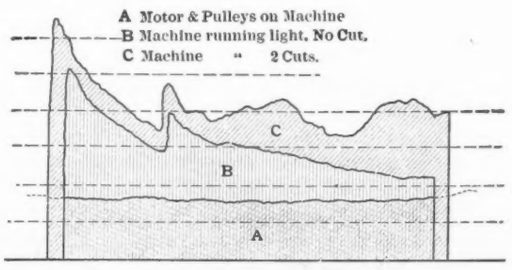



FIG. 3.

Power required per cubic inch of metal removed = .....308 h.p.
Or, amount removed per horse-power = .....3.25 cu. ins.

While the above item gives the rate as to capacity of motor

required it does not give the power cost rate. This can be obtained by taking the power consumed during the complete cycle of movements and the actual amount of metal removed during the cycle. Thus it is seen that the average power used through the cycle was 13.6 h.p. and the quantity of metal removed was 8.26 cu. ins.; hence, the following:

Amount of metal removed per horse-power expended = .....607 cu. ins.
Amount of power used per cubic inch of metal removed = .....1.64 h.p.

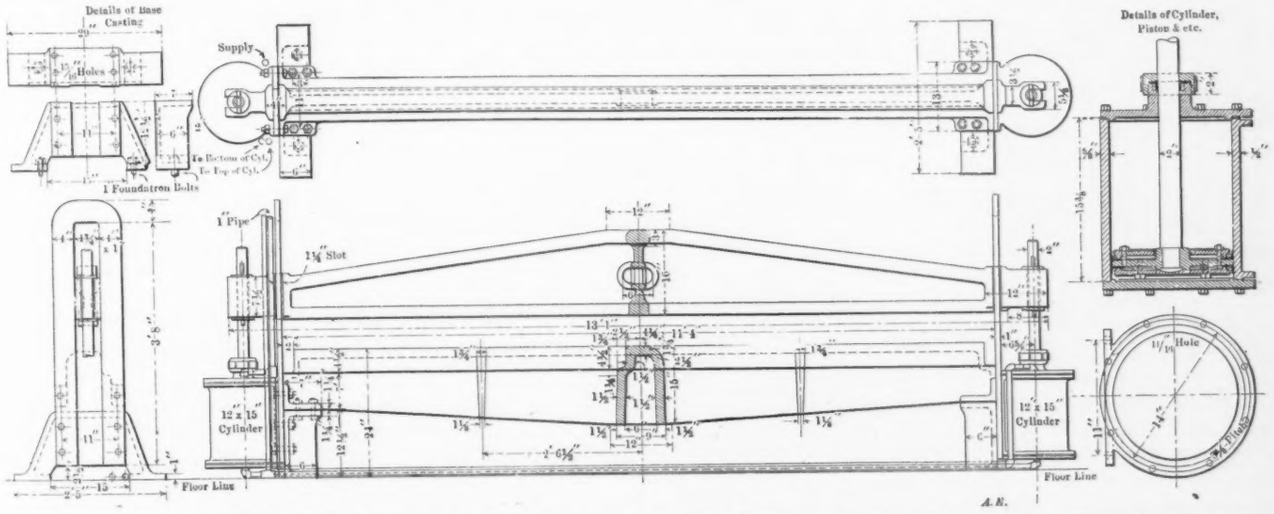
From the data given the total amount of power could be very closely arrived at by making proper observations and timing the various periods of running under cut, running light, etc.

By taking the power used throughout the cycle under cut, and while running with no cut, the difference represents the actual power used in removing the metal. Referring to the accompanying diagram, Fig. 1 shows something over three consecutive cycles, taken while machine was cutting. Fig. 2 shows the same length of time with machine running but no cut being taken. Fig. 3 shows three sections of record strip superimposed for purpose of ready comparison. Comparison of the figures and the diagram will show also that the time required per cycle differed somewhat between running light and running under cut. In other words, as the load decreased the speed of motor increased somewhat, and consequently the time of cycle was shortened. These diagrams form quite an interesting exhibit of the power variation required for planer driving.

## COMPRESSED AIR FLANGING CLAMP.

BUFFALO, ROCHESTER & PITTSBURG RAILWAY.

Machines of this description usually require holes in the floor to accommodate the cylinders. These are objectionable. The design shown here is by Mr. W. R. Maurer, of the Buffalo, Rochester & Pittsburg Railway, the machine being in use at the Du Bois shops of that road (see AMERICAN ENGINEER, April and May, 1902). These machines often depend upon screws to adjust the stroke to the work. This one depends entirely upon air. Everything about the clamp is accessible and from the cross-sections of the beams it appears to be sufficiently stiff for satisfactory work. In other respects the engraving speaks for itself. We are indebted to Mr. Charles E. Turner, formerly superintendent of motive power, for the drawing.




DETAILS OF THE COMPRESSED AIR FLANGING CLAMPS IN USE AT THE DUBOIS SHOPS.—BUFFALO, ROCHESTER & PITTSBURG RAILWAY.

A School for Telegraphy and Stenography has been established by the Canadian Pacific Railway at Montreal, for the benefit of employees of the company. It is understood that promotions in the operating department will depend upon a knowledge of telegraphy. A tuition charge of $2 per month is required, and this is refunded to pupils whose attendance at the classes is 80 per cent.

EDUCATE YOUR SUCCESSORS.—Organization demands that we have somebody to succeed us, to follow us. Have you in your shop men working for you who are competent to take your place if you are called away, if you should be transferred to some other place? Possibly this has occurred to you; possibly not. I want to urge upon you very strongly the educating of the men under you—the men who are doing the work for you—the men who are making you a success. It is coming to be more and more recognized every day by those in charge of the education of children that it must begin when the child is young. The same thing applies to the men working in the shops. We must not only select those who appear to be bright and sharp, but we must make especial effort to increase the efficiency of our brothers by educating them in every possible way. In olden times, the foreman would not give up to anybody what he called his trade secrets. It was a mistaken policy—very mistaken. The man who makes a success does it not by doing himself all the work, but by having those who are subordinates do the work for him.—*S. W. Miller, before International Railway Master Boiler Makers.*

POROSITY TEST FOR PAINTS FOR METALLIC SURFACES.—On a slip of glass put a thin coating of dextrine (20 grams dextrine, 40 c. c. water, 30 c. c. alcohol) on a spot about 1½ ins. diameter. When thoroughly dry paint the surface of the slip, including the spot of dextrine, with the paint to be tested, one or several coats, as may be desired, to correspond to the conditions of use. When the paint is dry and hard, in service condition, the slip is immersed in water. If the film is porous, water soaking through will dissolve the dextrine, giving it a whitish color and causing the overlying paint to peel off.—*Dr. C. B. Dudley, before American Society for Testing Materials.*

RAILROAD MILEAGE OF THE WORLD.—According to statistics prepared by the *Archiv fur Eisenbahnwesen*, and translated in the *Railroad Gazette*, the railroad mileage of the world at the end of the year 1902 was 520,955 miles. Of this amount North America has 233,186, or 44.75 per cent.; North and South America and Australia, 53.33 per cent.; Europe has 183,997 miles; Asia, 44,358; Africa, 14,554; North America, 233,186; South America, 28,822; and Australia, 16,038 miles.

Remarkable Fuel Economy in Locomotives.—A record of 1.97 lbs. of coal per indicated horse-power hour in a locomotive on the Adriatic Railway, Italy, is given by Mr. Charles R. King in an interesting article in the *Railway Engineer*, April, 1904. This was done by one of the new 0—6—4 type, passenger locomotives, arranged with the cab and firebox in front. They are four-cylinder compounds.

(Established 1832.)

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## EDITORIAL ANNOUNCEMENTS.

**Advertisements.**—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

**Contributions.**—*Articles relating to railway rolling stock construction and management and kindred topics, by those who are practically acquainted with these subjects, are specially desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

**To Subscribers.**—*The* AMERICAN ENGINEER AND RAILROAD JOURNAL *is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper ought at once to notify the postmaster at the office of delivery, and in case the paper is not then obtained this office should be notified, so that the missing paper may be supplied.* **When a subscriber changes his address** *he ought to notify this office at once, so that the paper may be sent to the proper destination.*

## THE AGE OF THE AMERICAN ENGINEER AND RAILROAD JOURNAL.

A correspondent recently inquired concerning the statement printed on the editorial page of this journal to the effect that it was established in 1832, and asked whether it has been published continuously since that date. In answer to this the following statement was transmitted, which may also interest other readers of this journal:

The *American Railroad Journal* was first published January 2, 1832. It was the first railroad paper published anywhere in the world, and was issued weekly in New York City. The *Mechanic's Magazine* was united with it July 1, 1838, the combined title being the *American Railroad Journal and Mechanic's Magazine.* In November, 1846, the office of publication was in Philadelphia, and in January, 1849, again in New York. This publication was bought by Mr. M. N. Forney October 1, 1886, and in January, 1887, was consolidated with *Van Nostrand's Engineering Magazine.* This latter publication was established in 1869 by Mr. H. L. Holley. The combination title was the *Railroad and Engineering Journal,* and in January, 1893, it was changed to the AMERICAN ENGINEER AND RAILROAD JOURNAL. January 1, 1896, the AMERICAN ENGINEER AND RAILROAD JOURNAL was bought by Mr. R. M. Van Arsdale and consolidated with the *National Car and Locomotive Builder,* being published with the title of the *American Engineer, Car Builder and Railroad Journal.* January 1, 1899, the title was shortened to the AMERICAN ENGINEER AND RAILROAD JOURNAL, under which the publication has continued.

This journal has been published continuously since the year 1832, and it is the oldest railroad paper in the world.

## THE POSSIBILITIES OF THE RAILWAY MOTIVE POWER OFFICER.

The words of a retired superintendent of motive power in his argument for a better standing of the motive power department given in his article in this issue should be pondered by all who have to do with the management of railroads. This article is a statement of facts and also a warning which should be heeded and acted upon. No one who knows railroad mechanical methods at the present time and is in a position to compare them with the methods which have brought great commercial success to large industrial enterprises, need be told the importance of the arguments of this gentleman. Transportation by railroads presents some of the greatest problems of the time, and some of its most vital factors are mechanical. It is also true that some of the greatest possibilities in cost reducing methods are also mechanical. Real economies in locomotive operation and maintenance have only begun, and the need of the best equipped mechanical officers was never so great as now. The field for railway mechanical work is not as attractive as it ought to be and so important a matter should receive the thought of owners and managements without delay.

## APPRENTICESHIP—WILL IT TAKE CARE OF ITSELF?

This journal has been taken mildly to task for giving so much attention to the apprentice problem. This is done by an officer who is high in the councils of a large railroad system and who believes that "the apprentice problem is settling itself very nicely." With this view all who have studied apprenticeship and present methods of recruiting railroad service must positively take issue. Apprenticeship is certainly not taking care of itself, and the neglect of it by the railroads is a very serious matter. Pension plans, improved methods of management, and the most correct dealing with employees can never permanently improve the labor conditions in railroad shops unless the method whereby youths enter the shops and learn the work are put right. Of all present-day problems there is none more vital or important in possibilities for influencing the future than that of recruiting the ranks of the workmen, whether in the shops, on locomotives, on trains, and at the telegraph key. The railroad officer who establishes a proper apprentice system and follows it up with its logical accompaniments will go down into history as a great man as well as a public benefactor. It can and must be done. Who will do it?

## THE LOCOMOTIVE HAS GROWN IN 37 YEARS—HAVE OPERATION AND MAINTENANCE KEPT PACE?

Nothing could be done at this time to better point out the way to improve American railroad operation than to direct attention to progress in size and capacity of locomotives, as was done by Mr. W. H. Lewis in his presidential address before the Master Mechanics' Association.

Everyone who reads this comparison, thoughtfully, must necessarily be led to think of the progress in the work done by the locomotives and in methods of operation and maintenance. This suggests several questions which the president and general manager should answer: 1. Is the locomotive department as a whole advancing in scope and authority to correspond with the increased responsibilities of running and maintaining and loading big locomotives? 2. Is the roundhouse and locomotive terminal, except in a few isolated cases, properly equipped to meet the needs of big locomotives, worked as they are to-day? 3. Has the locomotive repair shop, considered generally, advanced to a degree adequate for best commercial results with these big engines? 4. Is any railroad taking proper precautions to prepare enginemen for their important work in running and firing the big locomotive of to-day? 5. Is any railroad following up its use of fuel as care-

fully as the stupendous proportions of the fuel bills renders absolutely necessary to the owners of the properties? 6. What better way is there to put these things right than to put the motive power department on a rational basis; giving necessary encouragement, authority, scope and responsibility; putting the control in the hands of those who best understand the requirements?

It is desirable that the owners of the properties should realize that their interests depend upon the answers which their managements can give to the question: "What are your locomotives doing?" One of the greatest, and perhaps the greatest, of the problems before railroads to-day, and the one with the greatest possibilities for improvement, is the locomotive problem.

Because of their significance and because of the other comparisons which they suggest, the remarks of Mr. Lewis in regard to progress in size and in performance are reproduced as follows:

In 1868 we had locomotives with cylinders 16x24, with 60-in. driving wheels, with tractive power of 8,000 lbs.; boilers 46 ins. in diameter, with 15 sq. ft. of grate area and 900 sq. ft. of heating surface, and weighing approximately 60,000 lbs., with 38,000 lbs. on the drivers. Engines of these dimensions were considered large. In comparison with this take our passenger locomotives, with cylinders 22x28 ins., 80-in. driving wheels, developing tractive power of 32,000 lbs., with boilers 70 ins. in diameter, carrying 220 lbs. of steam, with 54 sq. ft. of grate area and 4,000 sq. ft. of heating surface, weighing 219,000 lbs. with 141,000 lbs. on the driving wheels; or the latest freight locomotive of the Mallett articulated type, with cylinders 20 ins. and 32 ins. diameter by 32-in. stroke, with 12 driving wheels 56 ins. in diameter, boiler 84 ins., carrying 235 lbs. of steam, with 72.2 sq. ft. of grate surface and 5,585.7 sq. ft. heating surface, developing a tractive power of 70,000 lbs. when working compound, or 80,000 lbs. while working simple; the weight of such an engine in working order being 334,500 lbs.

Comparing the engines of 1868 with standard modern freight engines, we find that the boiler pressure has increased 120 per cent., tractive power has increased 296 per cent., boiler diameter 52 per cent., grate area 260 per cent., weight on drivers 272 per cent., total weight 259 per cent. As an example of the increase during the past seven years I take the liberty of quoting the increase of the engines on the Norfolk & Western Railway Company, which, I believe, will serve to indicate the general increase on most of the roads of this country. The increase in the number of locomotives during the past seven years has been 37 per cent., total increase in tractive power 79 per cent. Increase in tractive power per engine, 30.7 per cent. During this time freight ton mileage has increased 86.7 per cent. and freight ton miles per engine has increased 35.2 per cent. The freight ton miles per pound of tractive force has increased 4.23 per cent., and freight engine mileage has increased 55 per cent., the increase in average miles per engine being 13.18 per cent. The total tons of coal per 1,000 ton miles, 4.09 per cent. The average cost of repairs, expressed in terms of "freight engine miles," has increased but 2.03 per cent. and repairs, in terms of "tons one mile of freight," has decreased 14.96 per cent. Freight train mileage has increased 23.6 per cent., the average weight per train has increased 50.9 per cent., and average number of tons hauled per engine has increased 21 per cent. From these figures you will see that while the average tons per train has increased 50.9 per cent., the cost of repairs to locomotives, expressed in terms of "ton mile of freight hauled," has decreased 14.96 per cent. The great significance of these comparisons justifies the presentation of these statistics, which will not be easily comprehended unless one has an opportunity to analyze them at his leisure. These figures will be found in detail in the committee's report on coal consumption in locomotives, a duplicate of which appears in the June issue of the AMERICAN ENGINEER AND RAILROAD JOURNAL, in comparison with some data other than that of our own.

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The Grafstrom Memorial.—Friends of the late Edward Grafstrom, who lost his life in saving the lives of others in the Kansas floods last year, will be glad to know that the memorial fund has reached the amount of $5,500. Messrs. S. P. Bush, W. H. Miner and B. C. Sammons, trustees of the fund, will purchase an annuity for Mrs. Grafstrom. They have also engaged Mr. Lorado Taft, the sculptor, to prepare a bronze tablet, to be set up at Topeka.

## LONG STAYBOLTS, LEAKY FLUES AND WIDE FIREBOXES.

The following supplements the report of the discussions before the Master Mechanics' Association, printed last month on page 273:

Advisability of Reducing the Diameter of Staybolts and Reducing the Distance Between Them.—Mr. G. R. Henderson presented a table showing the pitch necessary in using bolts of from 1 in. down to ⅝ in. in diameter. Increasing the width of water spaces would help the staybolts. Few bolts broke within 2 ft. of the mud ring. Taking everything into consideration, increase of length was believed to be preferable to a reduction in diameter of bolts. Prof. Hibbard had found that reducing the diameter of staybolts between the sheets did not increase the life of staybolts. Mr. Mord Roberts gave testimony from experience which was very favorable to "flexible" staybolts. Mr. McIntosh also had had excellent results with such staybolts, which had practically eliminated breakage, not one of these bolts having been found broken in two years of service.

Leaky Flues in Wide Firebox Locomotives.—Mr. M. K. Barnum believed the trouble to be due to faulty firing, bad water and short distances between the grates and the bottom flues. Brick arches would probably help the flues. With good water, good firing and tubes of the same length there should be no more trouble with wide than with narrow fireboxes. Mr. Vaughan thought flue difficulties to be due to two causes, the first being overheating of the flue ends. Wide firebox engines were doing more work than narrow ones, which led to overheating. The other cause was sudden contraction from cold air passing suddenly through a portion of the flues. When newly fixed the tubes were strongly secured in the sheets, but after a while they became loose and the change of length caused leaks. Wide grates were difficult to keep covered, and holes for cold air were much more likely to occur in the fire and cause sudden contraction of the flues. Mr. Bentley (Chicago & North Western) had practically overcome flue failures by the use of water-treating plants. Relay engines, engine failures and delays in turning engines had become practically things of the past with him. With bad water nothing would improve the situation, but with good water very little care was required. He gave strong testimony in favor of water purification. In fact, all of the speakers emphasized the importance of good water.

Limit of Width of Soft Coal Burning Fireboxes.—Mr. Lawford H. Fry opened this discussion in place of Mr. Vauclain. Excess air through large grates and excessive high rates of combustion were both to be avoided. Mr. Fry quoted experiments illustrating the losses due to excessive air admission, which carried off a great deal of heat and reduced the temperature of the firebox. The limiting width of grates depended upon the quality of coal. It was desirable to use vertical inside sheets of fireboxes in order to facilitate circulation. Dr. Goss gave a word of caution against loss of efficiency due to excess air. With wide fireboxes we were bound to be concerned with this question.

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THE HEATING SURFACE OF SERVE TUBES.—The usual rule for measuring the heating surface of Serve tubes, which are now commonly used in foreign locomotive practice, is to take the whole internal surface which is in contact with the hot gases and reckon this as the heating surface. This was brought out in a recent discussion before the Institution of Mechanical Engineers, England.

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A GOOD REPORT OF PISTON VALVES.—"On the Eastern Railway of France piston valves have been used with great advantage; they have larger ports and experience shows that an economy of nearly 10 per cent. was secured by piston valves as against flat valves."—*Engineering.*

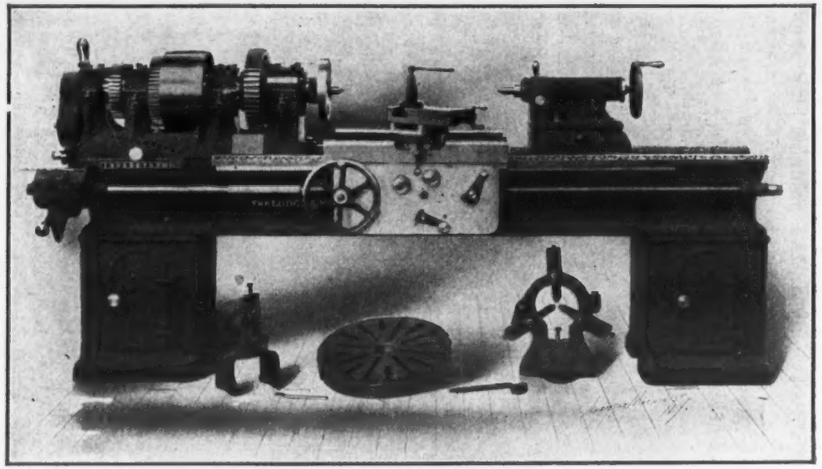


FIG. 1.—LATHE COMPLETE.

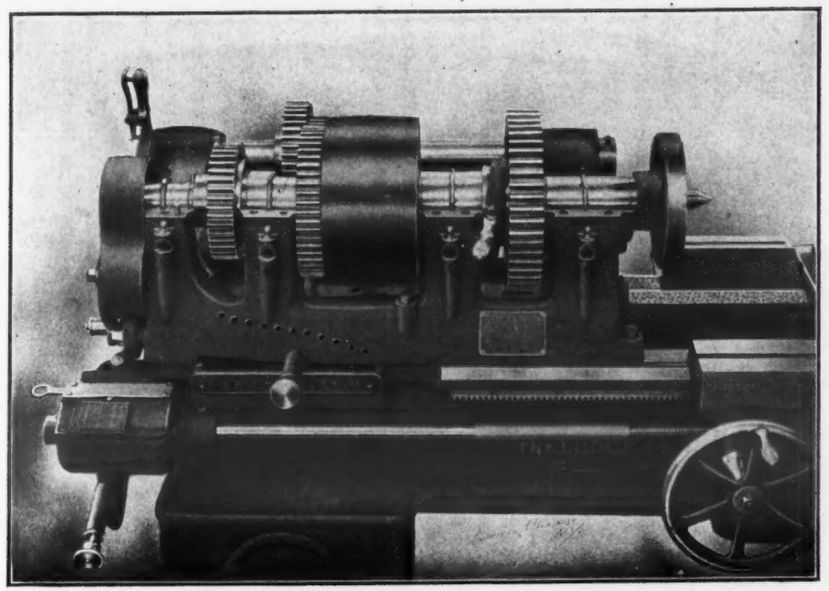


FIG. 2.—HEADSTOCK WITH BEARING CAPS REMOVED.

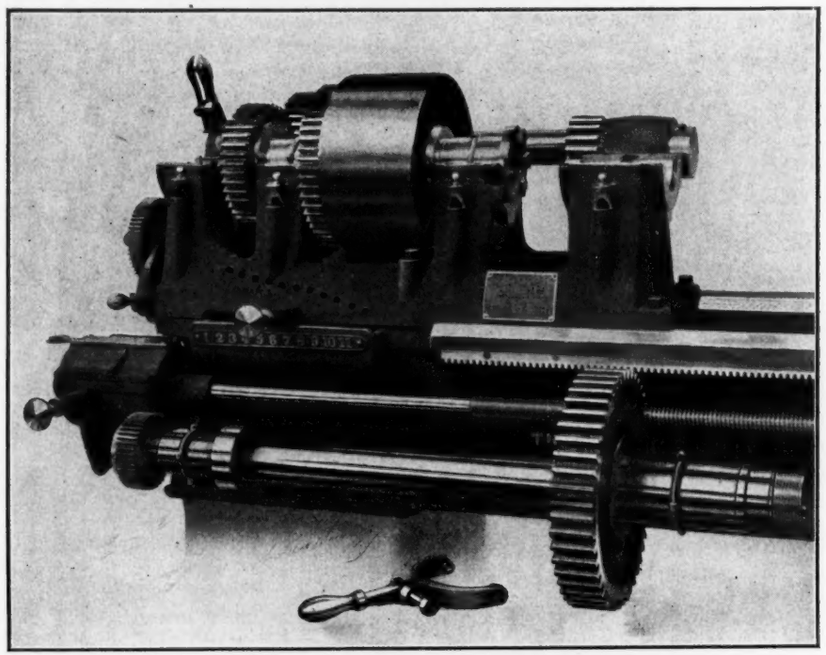


FIG. 3.—HEADSTOCK WITH SPINDLE REMOVED.

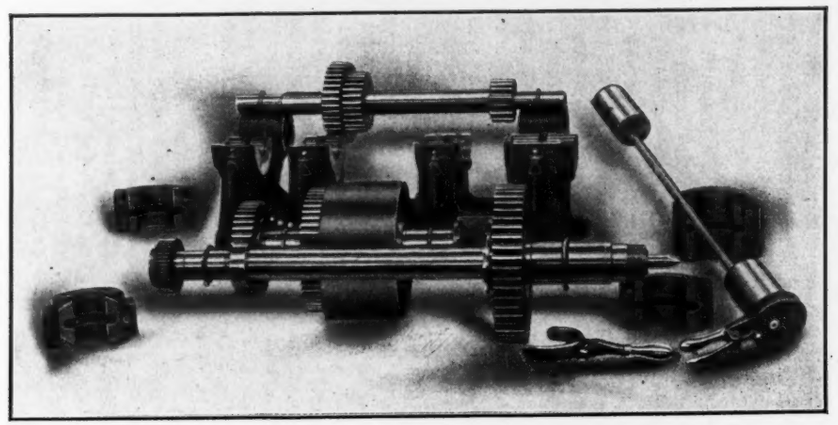


FIG. 4.—DETAILS OF HEADSTOCK.

LODGE & SHIPLEY 20 INCH LATHE WITH IMPROVED HEADSTOCK.

## A NEW DESIGN OF ENGINE LATHE HEADSTOCK.

A new and very interesting design of engine lathe headstock, which is radically different from that ordinarily used on belt-driven lathes, has recently been put on the market by the Lodge & Shipley Machine Tool Company, of Cincinnati, O. This headstock was designed especially to stand the severe service caused by the use of high speed tool steels and maintain its life and durability. To accomplish this arrangements were made to use a much wider driving belt than usual, and also to relieve the main spindle and its bearings of all the strain due to the pull on the belt, and to provide an improved device for oiling the bearings.

A 20-in. lathe, which is exactly the same as the standard Lodge & Shipley quick change gear lathe, except for the improved headstock, is shown in Fig. 1. Attention is at once attracted to the fact that the familiar cone pulley is missing and in its place is a single pulley with a very wide face and large diameter, and also that the main spindle is apparently supported by four bearings in place of two, as ordinarily used. Fig. 2 shows the headstock with the bearing caps removed. As a matter of fact, the two inner bearings are for the sleeve which carries the belt pulley, and the two outer ones for the main spindle, which passes through the pulley sleeve but does not touch it, as the sleeve is bored out to a ⅛-in. larger diameter than the diameter of the spindle. The belt pull, therefore, all comes on the pulley sleeve and its bearings, and the main spindle will preserve its alignment much longer and the life of its bearings will be much greater than with the old construction.

Fig. 3 shows the headstock with the main spindle removed. The pulley sleeve has a substantial jaw clutch on one end, as is clearly shown, and this engages with one which slides on the inside hub of the face of the larger gear. When the clutch is engaged, the main spindle of course revolves at the same speed as the belt pulley. At the other end of the pulley sleeve are keyed two gears of different sizes, one on each side of the bearing. On the back shaft are two sliding gears, either one of which can be thrown into mesh with the corresponding gear on the pulley sleeve, depending on the speed required. When not in use these sliding gears on the back shaft are located between the gears on the pulley sleeve. The ratios of the back gears are 3 to 1 and 9 to 1. The lathe with the direct run and the two runs of gearing has three speeds, and these, in connection with a countershaft with three speeds, give a total of nine spindle speeds. If the backing belt is not required on the countershaft it can be arranged to give six forward speeds which, in connection with the three speeds in the lathe, will make a total of 18 forward speeds.

The details of the headstock are shown in Fig. 4. The back shaft runs in self-oiling bearings, which are eccentric, and which are connected by a rod, as shown. The back shaft is hollowed out to take this rod.

Deep oil wells, which hold at least a pint of oil, are cast into the main spindle and pulley sleeve bearings. Brass rings, which have outside projections, are mounted on the spindles and arranged to turn with them. Holes are drilled into the projections on the rings, and these dip up the oil from the wells and, as they pass over the centre, drop it on the spindles. The construction of the bearings is such that the oil cannot get out of them, and the oiling device will run at least three months at one oiling. On the front of each of the bearings will be noticed a lug. These lugs are bored out and connected to the oil wells. The front part of each lug is then partially cut away, so that when a glass tube is inserted in the lug the level of the oil in the well can be seen.

## POOLING OF LOCOMOTIVES—DISADVANTAGES.

In a report on the subject of coal consumption of locomotives a committee of the Master Mechanics' Association made the following observations with respect to pooling:

Theoretically, the pooling of locomotives is advantageous, but there are many conditions which detract from the theoretical benefit of such method of handling when applied in practice. It may happen that engines pooled at different terminals will run over not only one division but a number of divisions and come in contact with various conditions affecting their economical operation, and the interest manifested by the men who operate the engines and those who care for them at terminals is diminished, resulting in a decreased efficiency in their performance. The pooling system has a demoralizing effect on the interest which is taken in the maintenance of the engines and their operation by the enginemen and firemen, resulting ultimately in less loyalty to the company which they serve. However, in numerous instances pooling is necessary, and where such is the case it cannot reasonably be expected that motive power can be maintained with as little expense as can be done with regularly assigned engines. The attention to detail of maintenance in keeping the motive power in serviceable condition without continual shop repairs is the keynote to good operation and economy, and is more likely to be obtained under a regular assignment where each man runs one particular engine than where one man runs forty engines. With a regular assignment each engineman becomes not only an inspector but an educator for the particular fireman who may be assigned to him, and a certain pride attaches to both men to maintain and have maintained that part of the property of the company which is entrusted to their care.

The result of pooling engines is further shown by the inability of firemen to cope with the differences in designs of engines as well as can be done when they are regularly assigned to one engine, especially where conditions warrant the use of both wide and narrow firebox engines. The care with which wide firebox engines should be fired is not generally appreciated by the men. This is perhaps largely the cause of the numerous troubles due to leaking which are experienced with this type of engine. It is much easier to maintain an even fire on a small grate than a large one, and the tendency with the large grate to allow different temperatures at different parts of the fire is considerably more than obtains with the small grate, hence the necessity of additional care on the part of the men operating an engine with a wide firebox and relatively large grate area.

## ROLLER BEARINGS FOR LINE SHAFTS.

In the course of a paper on "Electric Power in Workshops," by Mr. J. T. Irwin, before the Rugby Engineering Society, the author gives the following results of a test regarding the relative powers absorbed by the friction of journal and roller bearings. The figures given show the power taken on a line of shaftings, first, when fitted with cast-iron swiveling bearings 14¼ ins. long; and, secondly, when fitted with patent roller bearings 16¾ ins. long, so constructed as to allow of a certain amount of elasticity. The shafting was 124 ft. long by 3½ ins. diameter, and was supported by 13 bearings in each case. The shafting drove 26 machines, 6 lathes and boring mill gearing:

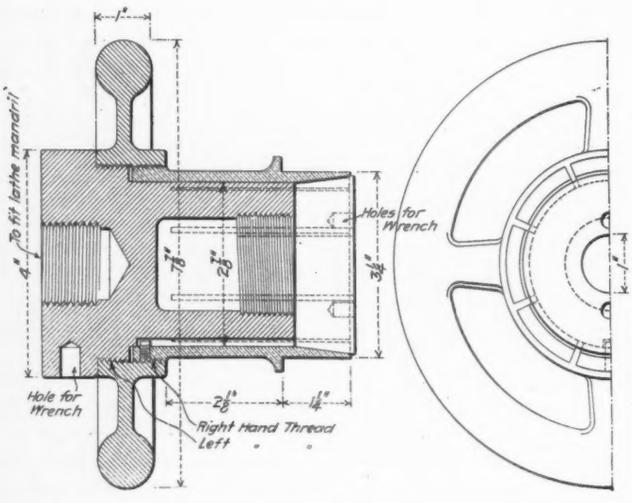
| Plain Bearing. | | Roller Bearing. | | |
|---|---|---|---|---|
| Starting. b. h.p. | Running. b. h. p. | Starting. b. h. p. | Running. b.h.p. | Remarks. |
| 14 | 1.9 | 10 | 1.2 | Running shafting alone. |
| 20 | 6.8 | 15 | 5.5 | Shafting and countershafts. |

From the above it will be seen that when using roller bearings the starting current required was much less, and also the friction load, which is more important, the advantage in favor of the roller bearings being about 37 per cent. with the shaft running light, and about 20 per cent. when loaded.—*The Mechanical Engineer.*

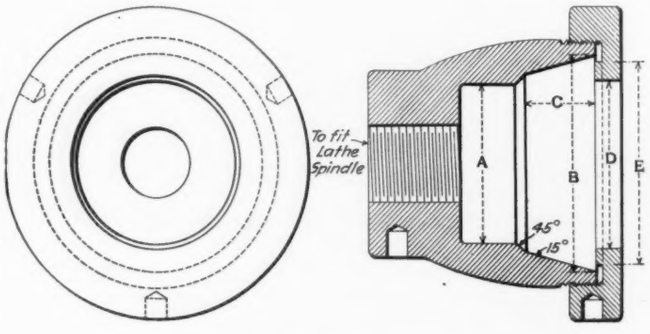
## CHUCKS FOR TURNING AND BORING METALLIC ROD PACKING.

A correspondent asks us to illustrate the chucks used by the United States Metallic Packing Company for turning and boring the packing manufactured by them. This company has courteously responded to a request for information with the accompanying drawings. Because of the great importance of proper fitting of rod packing, special attention should be given to these chucks.

One of the chucks is used to turn up the outside of the rings. It is made to fit the spindle of the lathe and is adapted to rapid work. The proper way for railroads to manufacture their own packing rings is to cast the rings separately and on a cone the size of the turning chucks. After facing the rings off separately, all three of them should be placed on this expanding chuck and the outside turned to conform to the interior of the vibrating cup. After this is done the rings should be put into the boring chuck and bored to the desired size.




EXPANDING CHUCK FOR TURNING OUTSIDE OF PACKING.




CHUCK FOR BORING PACKING.

SIZES OF CHUCKS (INCHES) FOR BORING MULTIANGULAR PACKING-RINGS.

| Diameter of Rod. | A. | B. | C. | D. | E. | Diameter of Rod. | A. | B. | C. | D. | E. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4½ | 4⅝ | 6 | 1¼ | 4¾ | 5¾ | 2⅝ | 2¾ | 3¾ | 1 3-16 | 2⅞ | 3½ |
| 4¼ | 4⅜ | 5¾ | 1 3-16 | 4½ | 5½ | 2½ | 2⅝ | 3⅝ | 1 3-16 | 2¾ | 3⅜ |
| 4 | 4⅛ | 5½ | 1 3-16 | 4¼ | 5¼ | 2⅜ | 2½ | 3 7-16 | 1 3-16 | 2⅝ | 3 3-16 |
| 3¾ | 3⅞ | 5 3-16 | 1 3-16 | 4 | 4 15-16 | 2¼ | 2⅜ | 3¼ | 1 | 2½ | 3 |
| 3⅝ | 3¾ | 5 | 1 3-16 | 3⅞ | 4 25-32 | 2⅛ | 2¼ | 3⅛ | 13-16 | 2 5-16 | 2⅞ |
| 3½ | 3⅝ | 4 13-16 | 1 3-16 | 3¾ | 4 9-16 | 2 | 2⅛ | 2 15-16 | 13-16 | 2 3-16 | 2 11-16 |
| 3⅜ | 3½ | 4 11-16 | 1 3-16 | 3⅝ | 4 15-32 | 1⅞ | 2 | 2 13-16 | ¾ | 2 1-16 | 2⅝ |
| 3¼ | 3⅜ | 4 7-16 | 1 3-16 | 3½ | 4 3-16 | 1¾ | 1⅞ | 2¾ | 23-32 | 1 15-16 | 2½ |
| 3⅛ | 3¼ | 4¼ | 1 3-16 | 3⅜ | 4 | 1⅝ | 1¾ | 2½ | 11-16 | 1 13-16 | 2 5-16 |
| 3 | 3⅛ | 4⅛ | 1 3-16 | 3¼ | 3⅞ | 1½ | 1⅝ | 2⅜ | 11-16 | 1 11-16 | 2⅛ |
| 2⅞ | 3 | 4 1-32 | 1 3-16 | 3⅛ | 3 13-16 | 1⅜ | 1½ | 2⅛ | ⅝ | 1 9-16 | 1 15-16 |
| 2¾ | 2⅞ | 3 15-16 | 1 3-16 | 3 | 3 11-16 | 1¼ | 1⅜ | 1 15-16 | ⅝ | 1 7-16 | 1 11-16 |

The interior of the boring chuck is bored to correspond exactly with the inside of the vibrating cup, so that when the metal rings are in position to be bored they are in the same position with reference to the cup as they occupy on the engine. This insures accuracy and the rings must necessarily be bored concentric with their exterior surfaces.

There has been a tendency among railroad men toward the belief that metallic packing need not be fitted at all carefully and that it will take care of itself when put into service. Everything is satisfactory if piston rods are always smooth and crossheads travel in line, provided the packing is properly fitted when applied. It is necessary to follow systematic methods with respect to packing and it is hoped that the description of these chucks will contribute toward an improvement. The accompanying table gives the various dimensions of the boring chuck for different diameter of rods.

## LOCOMOTIVE TERMINALS.

In a paper read before the Master Mechanics' Association Mr. Robert Quayle outlined the elements of a successful and adequate round house establishment, and among other things enumerated week spots usually found, as follows:

"Insufficient tracks for storing engines; poor coaling facilities or coalhouse too far from roundhouse; sandhouse badly located or inefficient; water supply improperly located or inadequate; cinder pits not long enough or so located that engines have to run a long distance after fire is dumped; cinder car track not depressed enough, causing unnecessary shoveling; lack of a wideawake man outside, who should, while working as a hostler or in some other capacity, have supervision over clinker pit, sandhouse, coal shed and other men working in the vicinity; turntable too small or weak and not power driven, causing more time to be spent spotting engines and turning them than is absolutely necessary; a roundhouse too small to get engines inside and close the doors, or one that is improperly lighted and ventilated; a poor roundhouse foreman; a poor engine inspector; washout facilities not arranged to wash out with hot water, or to have at least a pressure of 100 lbs. per sq. in.; drop jacks that won't drop; cinder floors; poor method of giving out work and checking it up; poor discipline among shopmen; a machine shop stocked with obsolete tools, or so located that men waste time running back and forth; a storehouse minus necessary material; a heating system that won't heat properly."

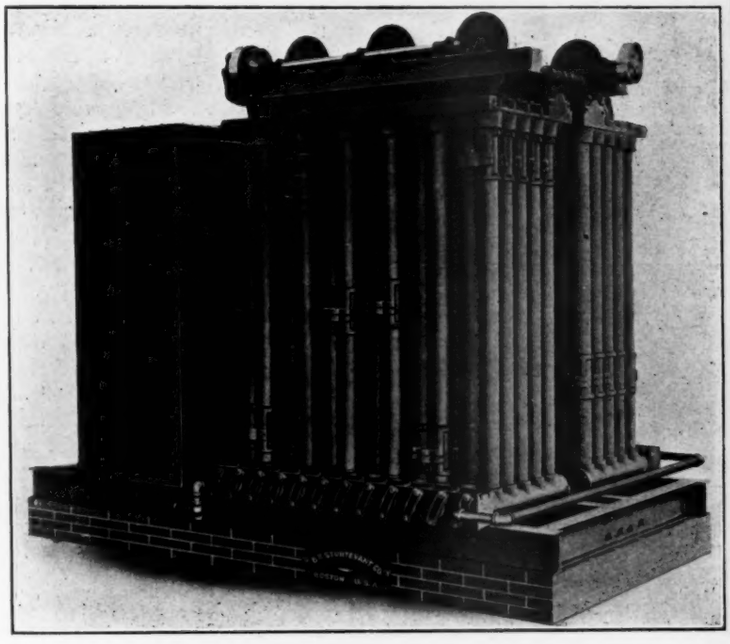
Under the head of roundhouse organization Mr. Quayle said:

"There should be a good, live foreman in charge, who is responsible to the master mechanic. All of the men working inside and out should be amenable to his orders; such a man, if a firm disciplinarian, and one who has the good will of the men and is quick to think and act, is invaluable. Under him should be an assistant who is familiar with the engines, enginemen and workmen; it should be his duty to give out the work and see that it is properly done, keeping check of the men who have done the work, so that in case it becomes necessary at some future time to locate them there would be no difficulty in doing so. A good staff of machinists, boilermakers, truckmen, helpers, boiler washers, wipers, engine inspectors, etc., is indispensable, all having their duties outlined so that there will be no friction in promptly doing the work. Fair and straightforward treatment of the men will in return get, in most cases, cheerful service. Proper records must be kept of the numerous periodical inspections that are called for. The engine-house in and out register should be entered up daily, and a check of engineers and firemen who are laying off or sick is useful to locate and round up men in case of a shortage."

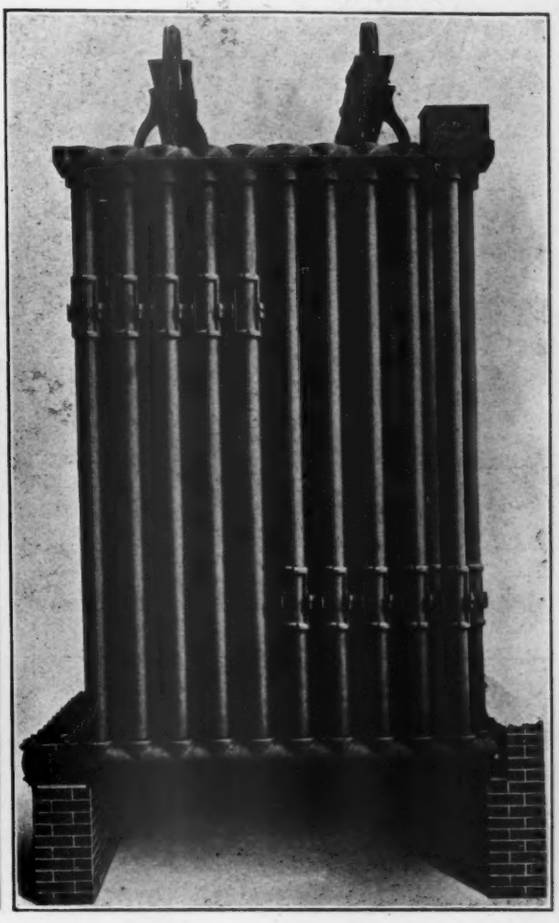
## THE STURTEVANT ECONOMIZER.

The economizer developed and installed in a number of successful power plants by the B. F. Sturtevant Company will interest the readers of this journal in connection with the important question of power plant economy. This economizer is a logical adjunct to the well known mechanical draft apparatus of this company, and is simple, strong and accessible. Its object is to utilize nearly all of the heat of the waste gases, which is accomplished by means of staggered pipes. This feature, by the way, constitutes a strong point of this economizer.

This is not an experimental construction. It is a development which has an established place through a number of commercial applications. It is adapted to new installations and also to application to old power plants, and by the use of two groups of sizes, the "Standard" and the "Pony," it covers all ranges of capacity down to about 50 h.p. The former size is generally used for boiler capacities of 350 h.p. and over, while the latter ranges from 50 to 500 h.p. It has been generally believed that only large plants offer suitable opportunities for the application of economizers, but this system provides equally convenient apparatus for relatively small plants, the saving being in the same proportion in small as in large plants.



THE STURTEVANT PONY ECONOMIZER, SHOWING FAN.



THE STURTEVANT STANDARD ECONOMIZER.

The effectiveness of economizers is usually measured from the increased temperature of the feed water, whereas it should be measured by the saving in fuel and also in boiler repairs. An economizer renders a large quantity of very hot water always available, and this insures hot feed water at a nearly uniform temperature, which greatly prolongs the life of boilers. Much of the scale-forming impurities of the feed water are deposited in the tubes of the economizer instead of in the boiler. These tubes are straight, and easily cleaned.

By a careful design the Sturtevant construction is such as to appeal to the engineer, who always has in mind the important question of maintenance. The tubes are of cast-iron, fitted into the headers with tapered iron to iron joints, made perfectly tight by hydraulic pressure. These tubes may be easily removed and replaced for repairs, and every tube is accessible for interior cleaning. The staggered arrangement of tubes is urged as a strong point of this economizer, as it breaks up the streams of gases and forces them into contact with the tubes. The bolts which hold the outside caps in place are not in the water in the tubes, and are not subject to deterioration by rust. Instead of pipe manifold headers, cast-iron wall boxes are used, which avoid many troublesome pipe joints and provide structural strength to the economizer for the proper support of its weight, distributing it uniformly along the foundations. Scrapers for cleaning the smoke surfaces of the pipes, safety relief valves to guard against excessive pressure, sediment blow-off valves and cast-iron soot-pit doors are provided.

These economizers are used with and without mechanical draft, which does what an ordinary chimney is incapable of doing. Its cost is from 20 to 40 per cent. of that of a chimney; its intensity permits of using finely divided or low grade fuel; it makes possible the utilization of flue gases which a chimney wastes in producing draft; it is independent of the weather; is automatically regulated to maintain constant steam pressure; decreases smoke; increases the capacity of an existing plant; serves as an auxiliary to a chimney already overburdened, and saves space. In conjunction with mechanical draft an economizer provides an ideal arrangement. Further information concerning this economizer may be obtained from The B. F. Sturtevant Company, Hyde Park, Mass.

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Overloaded Freight Cars.—In a paper before the St. Louis Railway Club, Mr. Waughop cites cases of cars with a marked capacity of 80,000 lbs. which are regularly overloaded with 122,000 lbs. of coal. These cars were billed at their marked capacity, therefore the road received nothing for hauling the excess. The author of the paper said: "Railway companies should, in my opinion, mark all cars with but one capacity stencil, and that should be the limit capacity. When a shipper goes beyond that marked limit, all excess should be confiscated by the railways and sold for the benefit of the car department."

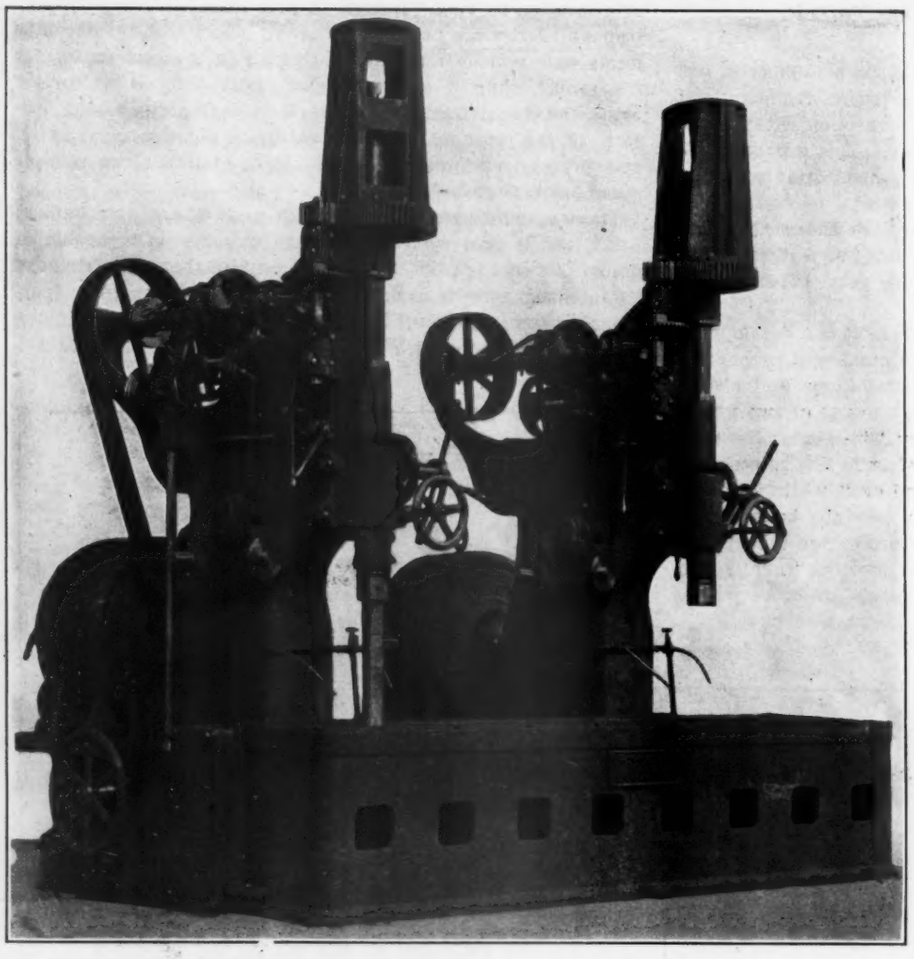


FIG. 1.—DOUBLE SPINDLE BORING MACHINE.—BAKER BROS.

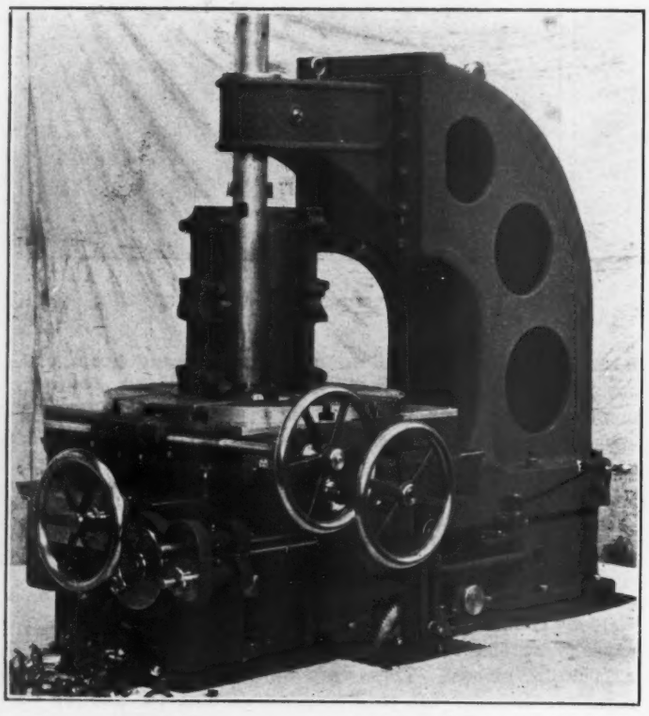


FIG. 2.—30-INCH DRAW-STROKE SLOTTER.—BAKER BROS.

A well designed gas producer and gas engine should develop an indicated horse-power per hour for a carbon consumption of 0.75 lb.—*B. H. Thwaite.*

## SOME NEW DESIGNS OF MACHINE TOOLS FOR RAILROAD SHOPS.

These tools, which are manufactured by Baker Bros., of Toledo, O., were designed especially for use in locomotive, railroad and engine works, and were made unusually heavy, substantial and complete in order to successfully meet the severe demands caused by the use of the most modern methods in machine shop practice.

The heavy double spindle boring mill, shown in Fig. 1, was designed for such work as boring out connecting rods and for heavy facing and counter-boring operations. The two spindles with their frames and driving mechanism are entirely independent, but are mounted on the same base. The frames are adjustable along this base so that the distance between their centres can be regulated to suit conditions. The left hand frame can be adjusted by power. The maximum distance, centre to centre of spindles, is 9 ft. 6 ins., and the minimum is 3 ft. 4 ins. The distance from the centre of the spindles to the frame is 20 ins., and each spindle has 24 ins. travel.

The bed plate, which is very massive, has a working table 11 ft. 2 ins. long and 24 ins. wide between the oil grooves, and the interior of this table forms an oil tank. Each spindle is provided with an oil pump for forcing the oil from this tank to the cutting tool. The spindles are triple back geared, and are each driven by a 220-v., 13-h.p., Westinghouse type S motor, which has a speed variation of 4 to 1. The motors are connected to the driving mechanism by belts and are supported by special brackets, which are cast on the frames. The motor controllers provide 15 forward and 6 reverse speeds. These, in connection with the triple back gears, give a total of 45 forward and 18 reverse speeds. The total range of spindle speed is from 3 to 90 r.p.m. Each spindle is provided with 20 rates of feed, varying from 0.005 to .125 in., and these feeds are all geared, and change from one to another can quickly be made by means of the change gear box on the side of the frame. The tool weighs 32,000 lbs.

Fig. 2 illustrates a very heavy design of 30-in. draw-stroke slotter, which was primarily designed for machining cast-steel locomotive driving boxes, but which is of course suitable for a great variety of other work, and will be found especially useful in machining long deep holes which the ordinary slotter cannot reach, and for key seating. Full automatic feeds are provided in all directions, and these and the hand feeds can readily be engaged by the operator standing in front of the machine. The length of feed is adjusted at the right side of the machine. The working table is 38½ ins. in diameter, with a 20-in. hole, and is only 32 ins. above the floor level, so that it is very convenient for the operator.

The ram is rack and pinion driven through a heavy train of gearing, and is counterbalanced. The reverse is accomplished by means of wide, shifting belts, which shift freely, and which have been found very satisfactory under heavy duty. The bar which carries the cutting tool can be made any shape or size up to and including 4½ ins. in diameter, and its size or shape

can readily be changed by changing the bearings. The boring bar is so supported that it is very rigid. The lower end is clamped into a long bearing in the ram and the bar is securely supported by a bearing in the table just under the work and also by a bearing in the upper arm. The machine has a wide range of feeds, and weighs about 16,000 lbs.

The following tests, which were made on one of these slotters, will give some idea of its strength and capacity: A steel driving box was slotted out in a circle 11¾ ins. in diameter and with a cut 11½ ins. long. A roughing and a finishing cut were taken off all surfaces, including the corners, in 28 minutes. The roughing cut was ⅜-in. deep with a ¼-in. feed, and the machine made 15 cutting strokes per minute. After the test 15 chips were picked up at random and were found to weigh 4 lbs. Another cut ¾-in. deep with ⅛-in. feed was taken on the same box. The cut was 11½ ins. long, and in 15 minutes the metal was removed for 22 ins. around the circle.

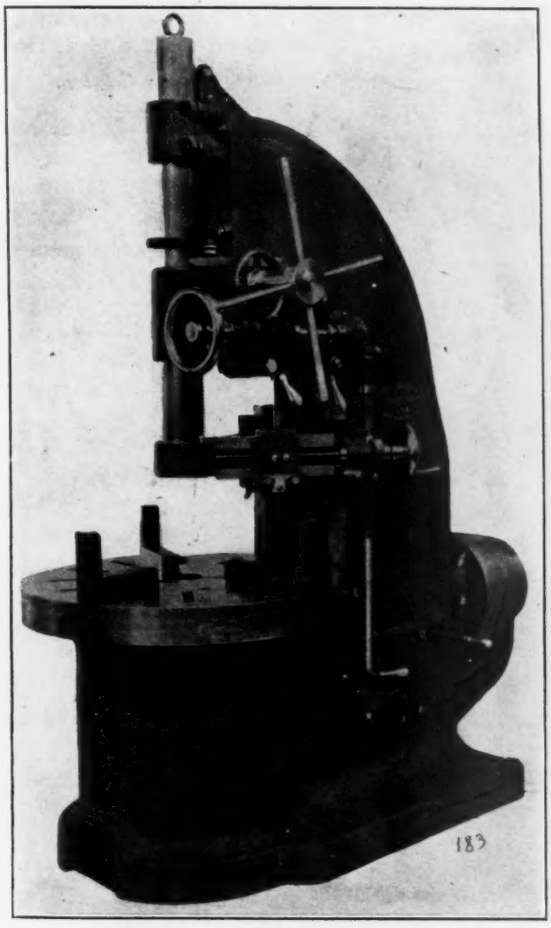


FIG. 3.—CAR WHEEL BORER.—BAKER BROS.

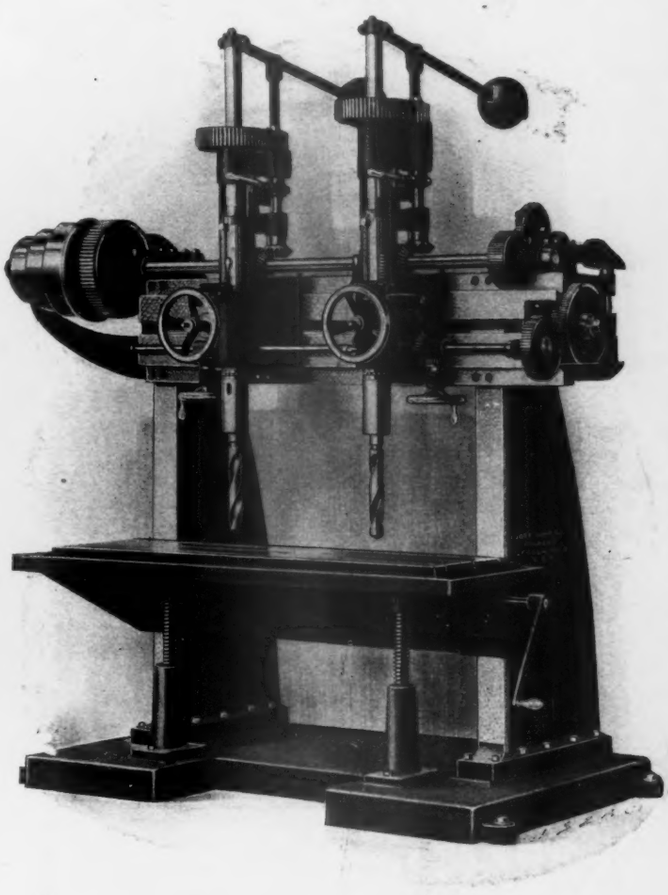
The car wheel boring machine, which is illustrated in Fig. 3, is fitted with a facing attachment that is of a rather novel and interesting design and is very rigid. The outer end is fitted with a bushing which guides the boring bar. The cross feed is geared and the vertical feed is operated by hand. The boring bar is 4¼ ins. in diameter, is fitted with a Morse taper socket, and is provided with long bearings, which are adjustable for wear.

The spindle is 4½ ins. in diameter and has a 2¾-in. hole running its full length for chips or for the boring bar. It is provided with a larger roller thrust bearing, and is fitted with taper adjustable bearings for taking up the wear. The frictional resistance is therefore small and the spindle is entirely free from vibration. The back gears can be thrown in by the lever, which is shown on the right hand side to the rear. The chuck is secured directly to the large driving gear. This machine is made in two sizes, 28-in. and 30-in., and weighs about 2,800 lbs.

## INDEPENDENT MULTIPLE DRILL.

This drill, shown in the half-tone, is manufactured by Foote, Burt & Co., of Cleveland, O., and is known as their No. 17. It is entirely new, and the design embodies some very interesting features.

The spindles are independent in both feed and motion, and either spindle can be instantly started or stopped without interfering with the other. The heads can be adjusted along the crossrail by means of a rack and pinion without stopping the machine. The minimum distance between spindle centres is 8 ins. and the maximum is 48 ins. The hand feed is provided for through worm gearing, and can instantly be thrown either in or out regardless of whether the machine is in motion or not. A positive automatic knock-off has also been provided which can knock off the feed at any point. This works very easily and smoothly, whether the tool is running light or under very heavy duty. The table adjusts vertically on uprights by



INDEPENDENT MULTIPLE DRILL.—FOOTE, BURT & CO.

means of jack screws and worm gearing. The miter gears are made of drop forged steel.

The machine has three positive gear feeds and six spindle feeds. It has a capacity up to 2¼-in. drills in solid metal, and weighs, complete, about 7,000 lbs. It can be used to very good advantage on work where two holes occur in the same piece, by operating both spindles simultaneously, or it can be used to equally good advantage on single hole work, one operator tending to both spindles and thus reducing the cost of the work.

Metallic Packings.—Under this title the United States Metallic Packing Company, 427 North Thirteenth street, Philadelphia, have issued a little pamphlet illustrating and describing their packings for marine and stationary engines. It comes from a firm having had an experience of 25 years in this line of manufacture. This pamphlet will interest railroad officials in connection with shop engines and engines of their floating equipment.

## McCANNA FORCE FEED LOCOMOTIVE LUBRICATOR.

The lubricator proper is placed on the regular standard for steam lubricators over the boiler in the cab. The actuating valve is placed at any convenient point on the engine where reciprocating motion can be obtained. The lever of the actuating valve is connected usually to the valve stem or rocker arm. This actuating valve is practically a rotary slide valve and is operated by a ratchet drive. It is connected to the main air drum on the engine by a pipe connecting with the air inlet shown in Fig. 3. The air ports are then connected to each side of the operating piston of the lubricator reservoir shown in Fig. 4. This piston is connected to a crosshead carrying two rods extending clear through the lubricator reservoir to another crosshead which operates the four pump plungers. These pump plungers have adjustable nuts, so that while the stroke of the operating piston is constant, the stroke of the pump plungers may be adjusted separately.

When the engine starts the reciprocating part communicates its motion to the arm of the actuating valve. This revolves the circular valve, admitting the air to one side or the other of the piston of the lubricator proper. This piston operates the pump, as explained above, and the oil is pumped to the point of lubrication by positive hydraulic pressure. At the point of lubrication is a check valve, shown in Fig. 4, similar to that shown on top of the lubricator, Fig. 3, which prevents the siphoning of the oil from the pipes and also prevents the back pressure blowing the oil out of the pipes. The gravity check valve is one of the principal features of the device. It consists of a cylindrical brass shell enclosing a hexagonal weight with a needle valve on its lower end closing the oil outlet. The oil to get to the point of lubrication has to raise this weight and needle valve from its seat, necessitating a pressure of about 25 lbs. It then flows through the outlet to the bearing. The weight being hexagonal and having space above and below it, and on account of its hexagonal form, all around it also, any back pressure from cylinder or air pump is exerted equally in all directions and there is no tendency to lift the valve from its seat, it being held down by gravity. One of these valves is located at each pump outlet at the oil reservoir and another at each lubrication point. The one over the reservoir serves two purposes, being provided with an additional outlet, by which the amount of oil being pumped can be tested at any moment, the oil thus showing dropping back into the oil reservoir.

This method of "bleeder" test has been adopted instead of the ordinary liquid sight feed, as glycerine or water through which the oil passes in the ordinary sight feed becomes clouded after a time and requires renewal.

It will be noted that this method of lubrication absolutely

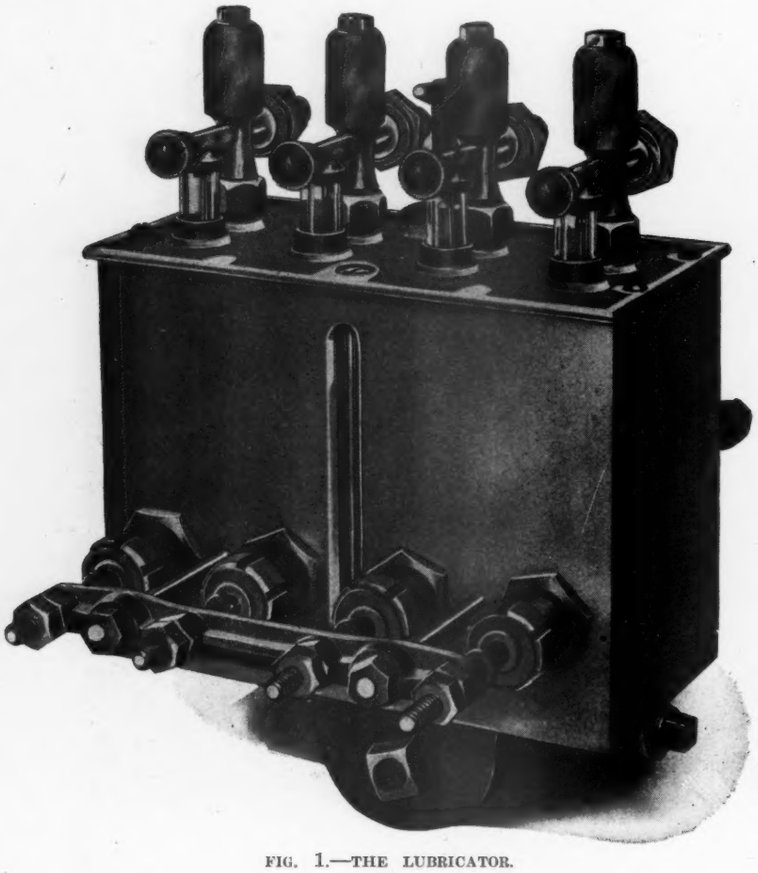


FIG. 1.—THE LUBRICATOR.

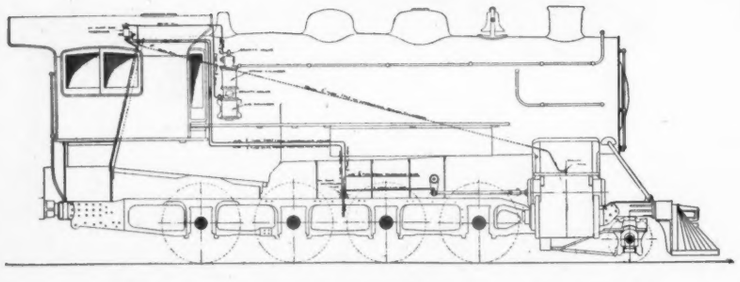


FIG. 2.—THE APPARATUS AS APPLIED TO A LOCOMOTIVE.

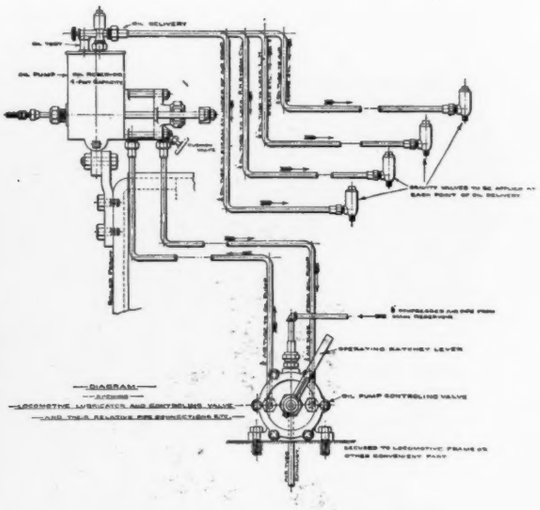


FIG. 3.—PIPING AND INSTALLATION.

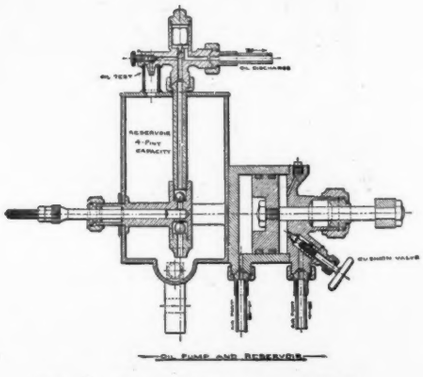


FIG. 4.—OIL PUMP AND RESERVOIR.

eliminates any chance of broken sight feed glasses and the injury which may result from such an accident.

Lubrication, therefore, is in direct proportion to the speed, as the faster the engine travels the faster the actuating valve is revolved and the faster, therefore, the pumps are operated.

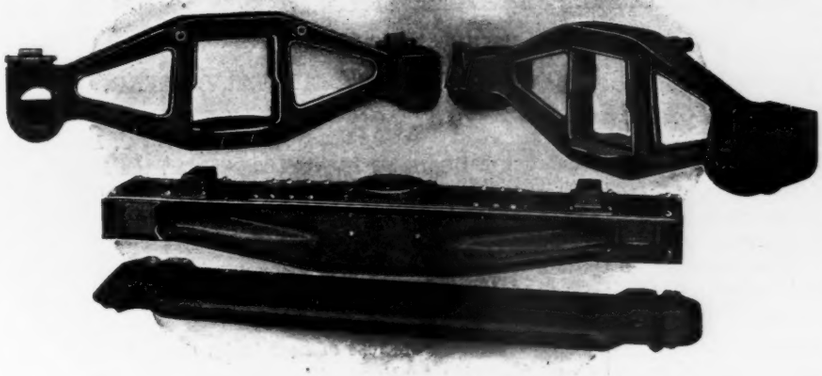
The stroke of each pump being independently adjustable, as much or as little oil can be fed to the point to be lubricated as is desired.

When the engine stops the oiling stops.

If an excess of oil is wanted at any particular moment on any of the bearings for any purpose, it can be obtained by operating that particular pump plunger by hand. Further information may be had from McCord & Co., Old Colony Building, Chicago, Ill.

## BETTENDORF CAST STEEL TRUCKS.

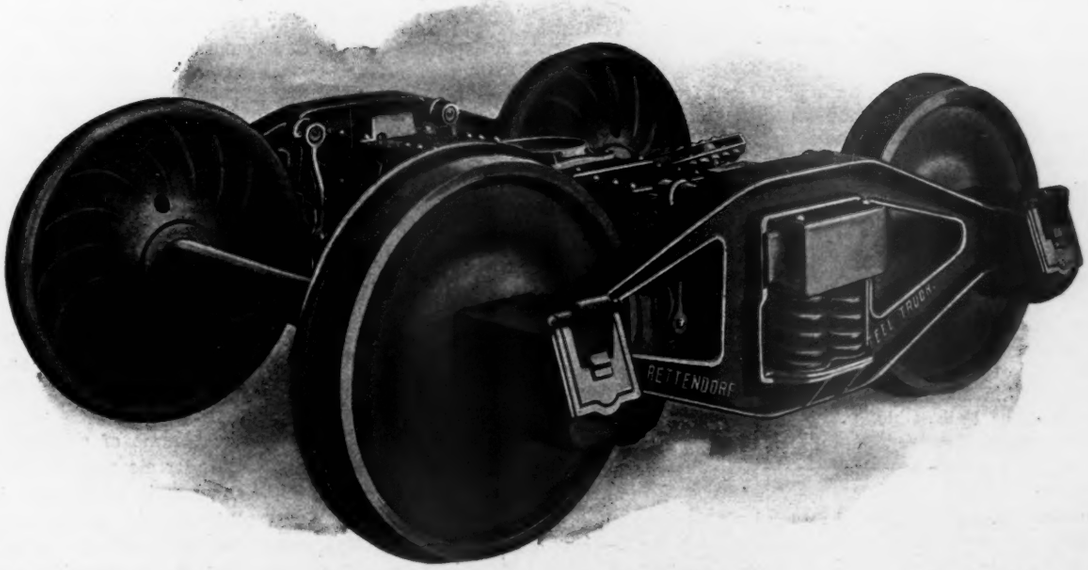
The new Bettendorf cast steel trucks exhibited at the recent conventions at Saratoga attracted attention because of the interest in the design and also because of the remarkably fine appearance of the steel castings. A one-piece truck side frame, including the journal boxes, in a single casting is of itself an interesting suggestion. A saving of about 1,000 lbs. per car is a distinct advantage, and to these are added a convenient construction, which avoids the use of bolts and nuts on the bottom of the frame. The quality of the material is broadly guaranteed, but should a journal box fail, the entire frame will be replaced at the cost of malleable journal boxes. This design may be made to interchange with the ordinary types of arch bar construction, and it also provides for top and bottom rollers.



As to repairs, this truck has been removed from under a car and completely dismantled in 9 minutes. It has been reassembled and replaced under the car in 8 minutes, a total of 17 minutes. The freight car trucks have coil springs under the bolsters, and the side frames finish at the ends in the journal boxes as shown in these engravings. For tenders an arrangement is provided for combining elliptic springs under the bolsters and coil springs in barrels over the journal boxes. These springs acting together are designed to produce the easy riding qualities of equalized swing-motion pedestal trucks. The coil and elliptic springs are given an initial load sufficient to support the light tender at the desired height.

The engravings of the separate parts indicate the manner of erecting this truck without bolts or rivets. The space between the columns is wide enough at the bottom to admit the end of the bolster, and when raised the guides enclose the columns. The form of the ends of the sand plank is such as to hold the truck together when put in place.

This is a bold step in truck construction, and is worthy of thoughtful attention. Additional information may be obtained from the Bettendorf Axle Company, Davenport, Iowa, who have developed the various "Bettendorf" car equipment improvements.

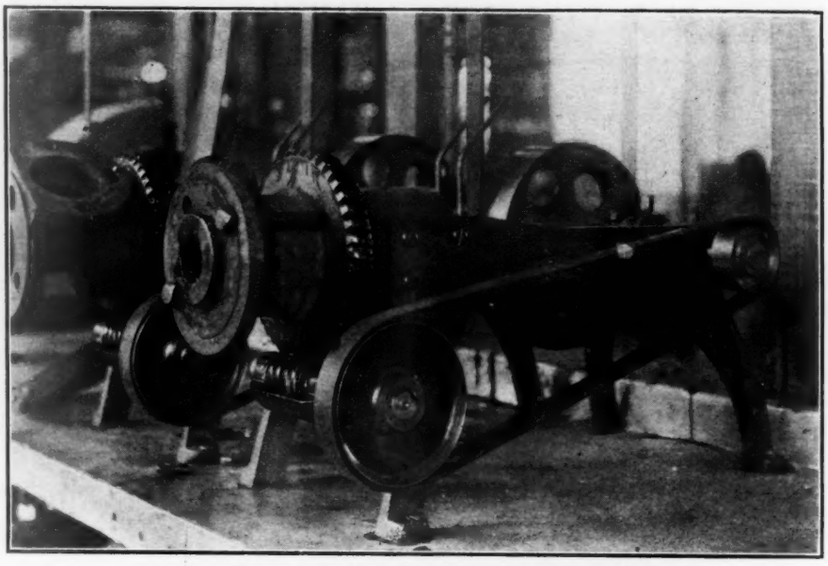



THE BETTENDORF CAST STEEL TRUCK.

## GRINDING MACHINE FOR TRIPLE VALVE PISTON RINGS.

Four of these machines are in use at the San Bernardino shops of the Santa Fe—and with them a boy, who tends all four machines—and grinds in from 65 to 70 triples in 10 hours. Each triple requires from 20 to 30 minutes, whereas a man at the vise cannot do the work in less than from one to three hours per triple, and cannot do it well at that.

The triple is bolted to the face of a worm wear, which is slowly rotated by a worm below. This worm is belt driven from the horizontal shaft at the right. On this shaft is a small eccentric and a driving pulley. The eccentric gives a reciprocating motion to the triple valve piston by means of a connecting rod and bar crosshead. By the combined motions the piston is reciprocated while the triple valve chamber is slowly rotated and a different portion of the bushing is presented to any given portion of the ring at every stroke of the piston. When the operator has secured the parts in position, he starts the machine and it needs no attention until the work is done; therefore the attendant may be given other duties. It is not to be supposed that this machine can take the place of an accurate bushing grinding machine, such as is employed at the works of the air brake manufacturers. This piston ring grinder was devised by Mr. J. P. Phillips, foreman of the machine shop at San Bernardino, who has applied for a patnet upon it.



SPECIAL GRINDING MACHINE FOR TRIPLE-VALVE PISTON RINGS.

A LESSON FROM EXPOSITIONS.—When we think of the marvels of enginering skill at the Chicago Exposition (1893) which learned scientific gentlemen decorated with blue ribbons and which were said to represent perfection in the art, and remember that the aforesaid "marvels" have, for the most part, been relegated to the scrap pile, and that in many cases the companies which produced them have vanished or been absorbed by more successful competitors, we realize that although "Time is short and art is long," eleven years is a long time in the art of electrical engineering. We should all note well the novelties in engineering at the St. Louis Fair. They will indicate the possibilities of the next decade and foreshadow the passing of most of what will there be displayed as the perfection of the art.—*R. H. Pierce in Western Electrician.*

Hollow Staybolts.—The following is abstracted from a paper by Mr. John Livingstone on the advantages of the Falls hollow staybolt. Hollowing the staybolt increases its flexibility, and the current of air passing through it cools it and thus reduces the expansion and also protects it from burning. Reducing the expansion of the staybolt lessens the liability of cracking the side sheets, and the molecular strains in the bolt itself are also reduced. When the solid staybolt vibrates or bends at the outer sheet the metal at its centre is crushed, thus causing internal expansion. Hollow staybolts are relieved of this. The ⅛-in. hole through the bolt furnishes a supply of oxygen to the firebox and gives sure warning if the bolt breaks. For these reasons the life of both the firebox and the staybolt is increased and the cost of repair reduced. Copies of this paper can be secured from C. M. Walsh, general manager, Falls Hollow Staybolt Company, Cuyahoga Falls, Ohio.

The Standard Brazing Company of Boston have executed a license with the Erie Car Works of Erie, Pa., and also with the Portland Company of Portland, Maine. Both of these companies are now equipped to do brazing of cast iron for the general trade.

Universal Directory of Railway Officials, 1904. Published by the Directory Publishing Company, 3 Ludgate Circus Building, London, E. C., England. Representative for the United States, E. A. Simmons, 83 Fulton street, New York.

This is the tenth year of publication of this directory, and its value increases with the annual volumes. It is compiled from official sources by Mr. S. Richardson Blundstone, editor of the *Railway Engineer*, and is undoubtedly as accurate as it is possible to make a work of this character. This directory is invaluable to those who conduct correspondence with foreign railway officials.

## ALLFREE-HUBBELL VALVE GEAR.

From a circular letter received from Mr. Ira C. Hubbell, in explanation of the Allfree-Hubbell valve gear, the following is taken:

"We increase the earning capacity of any class of locomotives converted to the Allfree-Hubbell type:

"First—By our system we greatly reduce cylinder condensation by reducing the radiating surfaces in clearance (ports) over 70 per cent., and by our valve-cylinder and saddle design protect the steam from loss of heat in its passage to the cylinder, and maintain continuously a hotter cylinder than is possible under any other design, insuring a high initial pressure of steam for each and every admission of steam to the cylinders.

"Second—Through our correction of the valve movement, by the simple, durable and economical addition we make to the existing link motion—we do not replace, displace nor change the links at all, nor in any way change their functions—we delay the opening of the exhaust port at all points of cut-off, and therefore hold the steam in the cylinder a greater portion of each stroke, and thereby necessarily increase the ratio of expansion, decrease the terminal pressure and get more work out of any given quantity of steam admitted to the cylinder.

"Third—By the addition made to the link motion, we also delay the closing of the exhaust port at all points of cut-off, thereby decreasing the volume in compression and thereby decrease the negative work of excessive back pressure in just that same proportion, and necessarily add just that much more to the positive work, the earning capacity of any given class of locomotives.

"Fourth—By decreasing the volume of compression, as we only can do, we reduce the cylinder clearance from 8 per cent. and over, to 2½ per cent., and less in cylinders, 20 x 26 ins. and never exceed 2⅛ per cent., and which enables us to save considerably over 1 cubic foot of steam for each and every revolution of the drivers that the locomotive moves under steam.

"We can increase the earning capacity of any existing locomotive, and will guarantee to do so, and will further guarantee to do this with no increase in the total cost per 1,000 miles run.

"My attention has just been called to the prophetic statement made in a paper read before one of our leading technical societies twenty years ago, by one of the best known steam engineers of the world, as follows:

"'I contend that there is at our command in the present practice of generation of steam on railways the means of getting better results both in time and extent of load carried, by more economical application of steam, and that such results are attainable with a change of valve and construction of the engine so that more of the true force of the steam will pass into work on the pistons instead of being wasted in friction in passing through constricted openings between the valve and ports, and I am not inaccurate when I declare that this view of the case is deserving of most careful and serious consideration.'"

## BOOKS AND PAMPHLETS.

Beveled Gear Tables, by D. A. Engstrom. Published by the Derry-Collard Company, 256 Broadway, New York. 1904.

This book presents a collection of tables and necessary explanations to enable any one to figure beveled gears without the use of trigonometry. It is not supposed to be an exhaustive treatise, but simply presents tables of dimensions of such gears as are generally found in practice, together with a few explanatory facts concerning the terms and diagrams. It is for beginners who have occasion to figure beveled gears, and is intended to entirely avoid the necessity for figuring. The author includes tables for every beveled gear from 12 to 47 teeth, inclusive. The various details of teeth elements and pitches, as well as construction and explanation of terms, are given in the earlier part of the work, together with explanation as to the use of the tables.

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Electric Railways *(Les Chemins de Fer Electriques)*. By Henri Marechal, *Ingenieur des Ponts et Chaussees*. 600 pages, 8vo, profusely illustrated. Printed in French. Published by Ch. Beranger, 15 Rue des Saints-Peres, Paris, France. Price, 25f.

This is a very complete and strictly up-to-date work upon the general subject of electric railway construction. It treats the subject under the headings of Generation of the Electrical Current, the Right of Way and Track, Transmission of the Electric Current, Railway Motors, Motor Cars and Locomotives, and General Uses of Electric Traction. The treatment of the subject of generating the current is interestingly handled, special attention being given to the steam turbine. Particular attention is also devoted to the overhead-trolley and third-rail methods of collecting the current, as well as to the various multiple-unit systems of train control. It is of interest to note that numerous references are made to the standards of practice in use in this country, which are supplemented by well-selected illustrations. Considerable space is devoted, at the end of the volume, to a discussion of the various monorail and other similar systems of transaction, and also includes an interesting treatment of the moving-platform method of transportation.

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Facts About Peat, Peat Fuel and Peat Coke. How to make it and how to use it. What it costs and what it is worth. By T. H. Leavitt. Illustrated. Boston, 1904. Lee & Shepard. Price, $1; postpaid, $1.10.

This little book of 115 pages states that peat is found in abundance in the United States, and that it may be cheaply and satisfactorily put into usable form as fuel by the use of machinery which bears the name of the author of this book, but the reader is not told enough about the process to convince him that peat will soon become a rival of coal as a fuel for use in large quantities. It is an interesting thing to know that peat is available in large quantities which are practically inexhaustible, and to be told that the process of preparation for the market is so cheap and simple; but the author of this book leaves much to the imagination of the reader, and does not present the right kind of facts to justify the conclusions which he evidently desires the reader to reach. It is not sufficient for him to state that condensed peat "made more steam than coal, and accomplished with ease the severest service required at the works."

Workshop Costs for Engineers and Manufacturers. By Sinclair Pearn and Frank Pearn, directors of Messrs. Frank Pearn & Co., Ltd., Manchester, England. Published by D. Van Nostrand Company, 27 Murray street, New York.

This work presents in complete detail a cost-keeping system as applied to the manufacturing of a line of steam pumps, and is presented in such a way as to be readily applied, without variation of principle or feature, to practically any operation involved in constructive work or manufacturing establishments. The book includes a complete set of blank forms, beginning with the pattern record and including material, time sheets and card-index records of the cost of the completed work, including labor and material. This system was developed and put into practice by the authors with a view of reducing to a minimum the routine work, also the number of blanks required in keeping the records. In this system chances of mistakes in ordering material are avoided by specifying in absolute detail on the cost sheet all of the material involved from a list of the component parts and quantities of the contract drawn up by the draftsman. Opposite each article is enumerated the cycle of operation through which it must pass, thus identifying the wages with the material. The work is divided into five parts, as follows: The nomenclature and registration of patterns and materials, the recording and analysis of labor, manufacturing the stores, and assembly work and contract or special work. While the book is specially intended for manufacturers, the principles involved are capable of adaptation to the keeping of costs in any shop involving repetitive operations, as in the manufacture of machinery of any kind.

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Westinghouse Industries.—This is the title of a very attractive pamphlet which has just been issued in behalf of the Westinghouse interests for distribution at the Louisiana Purchase Exposition. It describes and illustrates the works and products of the various Westinghouse companies, both in America and foreign countries. These interests include the Westinghouse Air Brake Company; American Brake Company; Westinghouse Electric and Manufacturing Company; Westinghouse Machine Company; Union Switch and Signal Company; Westinghouse, Church, Kerr & Co.; Sawyer-Man Electric Company; Bryant Electric Company; Perkins Electric Switch Manufacturing Company; Pittsburg Meter Company; R. D. Nuttall Company; Westinghouse Automatic Air and Steam Coupler Company; Security Investment Company; Nernst Lamp Company; Westinghouse Traction Brake Company; Cooper-Hewitt Electric Company; and the foreign companies, which include the Westinghouse Air Brake Company, Limited, with works in England and Germany; the Westinghouse Company, Limited, with works at St. Petersburg, Russia; the British Westinghouse Electric and Manufacturing Company; Société Anonyme Westinghouse; Westinghouse Electricitats-Actiengesellschaft; the Traction and Power Securities Company, Limited, of London; and the Canadian Westinghouse Company, Limited.

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Progress Reporter.—The third number of this paper, which is issued by the Niles-Bement-Pond Company, is a special one, describing their exhibit at the St. Louis Exposition. The more important machine tools in the exhibit are described and illustrated.

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THE DEVELOPMENT OF THE BRAKE SHOE.—The American Brake Shoe and Foundry Company of Mahwah, N. J., have just issued a very interesting pamphlet describing their exhibit at the St. Louis Exposition. The development of the brake shoe to secure durability, efficiency and strength and to wear the wheel tread where it is not acted upon by the rail is very carefully traced from the time that the first brake shoe was used to the present, and is nicely illustrated.

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AXLE LIGHTING.—In a small pamphlet the Consolidated Railway Electric Lighting and Equipment Company of New York City briefly describe their "Axle Light" system of operating fans in and lighting railway passenger coaches by electricity and also call attention to the advantages to be gained by the use of their system.

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AIR COMPRESSORS.—The Chicago Pneumatic Tool Company have issued a 72-page catalogue describing the air compressors built at their Franklin works. In addition to the illustrations and lists of sizes of the various compressors there is an interesting illustrated description of the constructive principles of the compressor. Several pages are devoted to information concerning the installation, adjustment and care of the compressors and there is also considerable information and several tables which will be useful to those interested in the use of compressed air.

BOWSER OIL CABINETS.—The adjustable measure oil cabinets made by S. F. Bowser & Company, Fort Wayne, Ind., are described in a leaflet which directs attention to the features of these oil storage facilities which render them a necessity wherever oil is required for machinery or lamps.

SKETCH PAPER FOR ISOMETRIC PROJECTION.—The Derry-Collard Company, 256 Broadway, New York, have gotten up pads of sketching paper for making drawings in isometric projection. This is the only practical perspective for machine drawings as it permits of making sketches to scale in any of the three isometric axes. The paper is very easy to use, and rapidity of sketching is quickly acquired. The paper is blocked in standard sizes, 6 x 9 ins.; 9 x 12 ins. and 12 x 18 ins., the prices being 25 cents, 50 cents and $1 each, respectively. This will be a great convenience for draughtsmen.

VALVES.—The Crane Company of Chicago have just issued two pamphlets and a booklet describing and illustrating their valves. One of the pamphlets describes the renewable seat and disc globe, angle and straightway valves for high pressure service. The globe and angle valves are designed for 225 pounds and the straightway valves for 250 pounds working steam pressure and are particularly adapted for locomotive work. The other pamphlet describes their self-packing radiator valves and self-packing globe and angle valves with non-rising stem. The booklet, which is known as "Special Catalogue No. 101," describes the Crane patent improved safety valves for all kinds of boilers. The locomotive pop valve is fitted with two regulators, one for moderate changes and the other for extreme changes in the set pressure.

AIR-COOLED ELECTRIC DRILL.—The Chicago Pneumatic Tool Company in a special circular No. 48 calls attention to the Duntley Air-Cooled Electric Drill which they have just placed on the market. The drill which is described weighs only 12 pounds and is adapted for drilling holes up to ½ inch in diameter in iron and boring up to ¾ inch in diameter in wood. By cooling the motor with air the difficulties heretofore experienced with small electric motors are overcome and its use is made practical. The motor can be wound for either 110 or 220 volts and the drill has a speed of 850 rev. per min. The electric wires are fitted with a connection plug to fit an incandescent socket and this plug is equipped with a cartridge fuse plug which can easily be replaced if burned out.

NEW ENGLAND RESORTS.—The vacation custom is now a fixture, and the summer resorts of New England because of their unexcelled beauty and variety appeal to everybody. The beautiful lake resorts among the pinelands of Maine or in the northern portion of New Hampshire and Vermont; the verdant valleys watered by freshening streams such as the Merrimac, the Hoosac, the Connecticut and the Ammonoosuc; the long and famous stretch of seacoast from Portland and east to the rocky Nahant; the impressive grandeur and wonderful attractions of the White Mountains; the favorite haunts among the Hoosac Mountains and the Deerfield Valley; and the numerous towns and villages famed for their historic association as well as scenic and health resorts are delightfully pictured in the series of six books containing beautiful halftone reproductions of these various resorts, each book containing thirty or more views neatly bound with the title of the book embossed in gold letters on the cover. These books are entitled "Lakes," "Rivers," "Mountains," "Seashore," "The Charles River to the Hudson," and "Picturesque." The price of each book is six cents or thirty-six cents for the entire set. This includes the postage; issued by the General Passenger Department, Boston & Maine Railroad, Boston, Mass. This department has also just issued a remarkably fine and comprehensive folder entitled, "Resorts and Tours," which illustrates and describes a large number of inviting trips and side trips to the beautiful places with which New England abounds. For the special use of those attending the encampment of the Grand Army of the Republic in Boston in August a folder has been prepared illustrating the many points of historic interest in that city These may all be obtained, upon request, from the passenger department.

## NOTES.

The Warner & Swasey Company of Cleveland, Ohio, announces that Mr. H. L. Kinsley will represent them in the East. Mr. Kinsley has been with Manning, Maxwell & Moore for the last five and a half years, and previous to that time was with the Hopedal Screw Company.

RAILWAY APPLIANCES COMPANY.—This company announces that they have been appointed exclusive agents for the United States for the railway trade of the Olds Motor Works of Detroit and Lansing, Mich.

LOCOMOTIVE & MACHINE COMPANY OF MONTREAL.—The directors have elected the following officers: President, Mr. A. J. Pitkin; first vice-president, Mr. J. E. Sague; second vice-president, Mr. R. J. Gross; controller, Mr. C. E. Patterson. The expenditure of $300,000 for improvements was authorized.

The Broderick & Bascom Rope Company, of St. Louis, closed their works for the day June 25 and sent their entire force of 300 employes and their families to the World's Fair, with all expenses paid. They were taken to the handsome and impressive exhibit of the company, and had the day in the grounds. Such an instructive and enteresting treat has a good effect on all concerned.

CROCKER-WHEELER COMPANY.—This well known electrical company announces that in addition to the engineering advice upon design and installation of electrical apparatus for shop equipment which they have been accustomed to give their clients, they have retained the well known firm of Dodge & Day, Modernizing Engineers, of Philadelphia, Pa., who will furnish gratuitously advice upon the latest ideas and results in shop practice.

NORTHERN ELECTRIC MOTORS.—The very attractive design and efficient application of these motors to machine tools have been frequently indicated in this journal but, inadvertently, the fact that the Gisholt Boring Mill, illustrated on page 277 of the July number, was driven by one of them was not mentioned. Because of the interest in the motor and also in the boring mill it is a pleasure to supply the omission now.

The American Nut & Bolt Fastener Company, Pittsburg, Pa., manufacturers of the Bartley Positive Fastener, shipped on July 6 an order from the Morden Frog & Crossing Company of Chicago, Ill., for 29,000 Bartley Fasteners to be applied on frogs and crossings of their manufacture. Large orders have been shipped recently to the Cleveland Frog Crossing Company of Cleveland, Ohio, Union Switch & Signal Company, Swissvale, Pa., and Lorain Steel Company, Johnstown, Pa.

The Crocker-Wheeler Company has made an arrangement with the celebrated engineers, Brown, Boveri & Company, of Baden, Switzerland, and secured their alternating current designs, patents and rights to manufacture in America, and have retained this firm as consulting engineers. The Crocker-Wheeler Company has put on the market alternating current generators, transformers and accessories, adapted to American practice, and opportunities to bid on this apparatus are invited. This company has contracted to furnish a 200-kw., 60-cycle, 440-volt alternating current generator for the Atlanta plant of the Procter & Gamble Company of Cincinnati and the field of alternating current works is entered with vigor.

The Walter A. Zelnicker Supply Company, St. Louis, report several recent sales of their "Zelnicker" portable wheel press. This company has an attractive exhibit in the Transportation Building at the fair, and are showing among other things this wheel press in operation, pressing wheels on and off axles. Blue prints and descriptive circulars will be furnished upon application. Many other of their specialties are exhibited, among them the celebrated "double clutch" car mover which this company manufactures. They report excellent sales of their car mover this year and that the factory is unable to turn them out fast enough. This company will send a sample of their lumber crayon for the asking, and guarantee it longer and better than any crayon on the market.

The St. Louis Transit Company, which operates the larger part of the street car system in St. Louis, has found itself short of power ever since the World's Fair began to attract large numbers of visitors. The traction plant was working at an almost constant 50 per cent. overload, and at rush hours the excess reached extreme proportions. The railway company have now applied to the World's Fair authorities for additional power, with the result that Governor Francis and the fair administration have, by contract, put at the service of the railway company during the day, from 2 p. m., until 7 p. m., when the loads are heaviest, the service of the huge Allis-Chalmers engine in the Machinery Building. This engine, which is coupled to a Bullock electric generator, and which, when operating at 75 revolutions per minute, at a steam pressure of 150

lbs., and operating non-condensing, is capable of developing 8,000 horse-power, is the central feature of the Machinery Building. From 8 p. m. until the fair grounds close this powerful unit supplies the current for the decorative lighting of the buildings and grounds, which forms the most conspicuous attraction of the exhibition. The lighting requires 200,000 incandescent lamps. The traction load which the engine and generator will now carry by contract between the railway company and the exhibition authorities will be at least 3,000 horse-power, to begin with, and may be much increased as the World's Fair crowds are augmented. It is this engine which has won at St. Louis the popular name of "The Big Reliable."

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The capital stock of the Standard Roller Bearing Company, Philadelphia, Pa., has been increased from $1,000,000 to $2,000,000. There will be immediately erected a 250-ft. addition to the machine shop and factory as well as an office building two stories in height. This addition will be devoted exclusively to the manufacture of roller bearings, etc., while an addition 50x125 ft., three stories in height, will be made to the ball plant. Two hundred and fifty thousand dollars will be expended in the construction of the buildings and in equipping them with machinery. Contracts for the building and some of the machinery have already been given and it is expected that all of the building operations will have been finished by October 1. Two years ago the Standard Roller Bearing Company purchased in Philadelphia about three acres of ground on the main line of the Pennsylvania Railroad, about fifteen minutes' ride from the center of the city. Upon this property was erected a modern up-to-date machine shop, with power house, forging and hardening departments in separate buildings. Possession was taken of this property January 1, 1903, since which time the company has built and installed its own brass and iron foundries, and at the present time does not purchase anything whatever in the open market except the raw materials for its foundries and steel from which to make bearings, manufacturing all other devices themselves. The business continues to grow so rapidly that it has become necessary to build the extensions above noted. For about one year past the plant has been running twenty-four hours per day and for the past six months the ball plant has also been running day and night.

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Manning, Maxwell & Moore report that they have just received a large order, amounting to between $150,000 and $160,000, from the Illinois Central R. R., for machine tools to be used in the various shops on the system. This order is the largest which has been placed for some time and includes a full line of railroad shop tools such as driving wheel lathes, steel tired wheel lathes, axle lathes, large and small engine lathes, brass lathes, car wheel borers, vertical and horizontal boring machines, radial drills, shakers, planers, slotters, bolt cutters, grinding machines, centering machines, punchers, shears, steam hammers, woodworking tools, and a full line of toolroom tools and milling machines. They have also secured an order for all the traveling cranes required in the shops of the system. They also announce that the Central Railroad of New Jersey has placed an order with them for a large number of radial drills, engine lathes, grinders and woodworking tools.

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## MASTER MECHANICS' ASSOCIATION.

THIRTY-SEVENTH ANNUAL CONVENTION.

SARATOGA, N. Y., JUNE 27 TO 29.

ABSTRACTS OF REPORTS AND PAPERS (CONCLUDED).

## LOCOMOTIVE FRAMES.

COMMITTEE—T. S. LLOYD, S. M. VAUCLAIN, J. E. SAGUE, REUBEN WELLS, S. HIGGINS, A. LOVELL.

Your committee endeavored to construct a composite drawing, in hope of illustrating in graphic form the combined experience as illustrated by the drawings furnished, but reluctantly had to abandon the idea after repeated ineffectual trials.

A careful scrutiny of the material conveys no information as to why the particular frames in question break; nothing to indicate *per se*, that the material from which the frames were made had anything to do with the fractures. The breakages reported are not confined to any particular locality; they show cracks in and about all pedestal jaws; in fact, as many fractures back of leading axle as in front of and about same; also that the fractures occur just as frequently in the solid parts as through the bolt-holes.

The total number of locomotives in the country is about 44,000. Percentage of total number of locomotives covered by the replies is 48 per cent.

The causes of fracture may be classified as follows: (*a*) Design. (*b*) Imperfect welds and faulty material. (*c*) Inertia of the boiler with reference to the frames, augmented by high cylinder saddles and accompanying high center of gravity of the boiler; the initial cause, the inertia of the boiler when front bumpers strike an obstruction or when brakes are suddenly applied. The fractures show mainly between the cylinders and front driver. All are not in agreement as to this, however, and attribute the class of breakage located between the cylinders and front driver to (*d*) Presence of water in cylinders, when accompanied by such arrangement of valves that prevents the water getting away quickly and freely.

A discussion, bearing mainly on point (*c*), furnished by one of the members, is as follows:

"There seems to be no question but that the fractures are usually located between the cylinder saddle and the rear of the first pedestal, but it should be further determined whether or not the cracks start from the bottom of the rail. If they do, then the bending moment due to the inertia of the boiler when the motion of the frame is suddenly arrested cannot be a cause of failure, because the bending moment induced by such force would put the top of the rail in tension and the bottom in compression, and the crack would therefore start from the top, as previously explained, except when coupling. If they start from the corner of the pedestal it is reasonably certain that the failure is caused by a loose bolt or light design of pedestal binder. It is very probable that the binder bolt will show a very much larger percentage of failures extending in the corner of the pedestal to the top of the rail than the clip pedestal brace, because of the difficulty of securing a bolt sufficiently large to prevent it stretching in service. Those failures which occur in the front of the pedestal cannot be assigned to this cause (unless the pound would strain the frame in a place of weaker section), and in failures of this nature the design of cylinder fastening and keys should be thoroughly examined. It might be well to point out that the bending moment induced by the pull of the drawbar would be at a maximum at a point between the front pedestal and the front cylinder. A stress from such a cause would start a crack from the bottom of the rail. If the frames break from a definite load or fiber stress, then a good grade of cast steel should give equal, if not better, results than wrought iron, and the steel should be of a moderately stiff grade. If, on the other hand, the frames break by a definite amount of distortion or bending, then wrought iron or soft steel would give better results, inasmuch as it would take a smaller force to bend this material a certain amount, and the fiber stress induced would therefore be considerably less in the case in which the stiff steel is used."

Professor Lanza has fully discussed the static loads and stresses on frames; these show that the frame is amply strong to resist any such stresses.

The inertia of the boiler in accelerating or retarding the train has also been given as a possible cause of breakage. Since frames never start to break from the top but always from the bottom of the rail, it is evident that the inertia of the boiler while the train is being retarded cannot be a cause of fracture, but the bottom of the rail is put in tension in overcoming the inertia of the boiler while the train is being accelerated.

From the calculations [Not reproduced.—EDITOR.] the following conclusions may be drawn:

1. The inertia of the boiler following the sudden application of brakes cannot produce a sufficient force to break the frame.
2. The inertia of the boiler due to the acceleration of the train, by acting with other forces, such as those produced by water in the cylinders, may bring about fracture.
3. The dynamic effect of the compression of water in the cylinders is the only force which, unaided, can cause failure of the frames by fatigue.

It may be well to point out that when the right side leads, the right side always pounds harder than the left. This is due to the fact that when the right crank passes the forward dead center the left cylinder is pulling forward, so that it aids the right cylinder in throwing the right box against the back jaw of the pedestal. The same is true on passing the back dead center, but when the left crank passes the forward center the right cylinder is pushing on the pin, thus subtracting from the left cylinder in pushing the left box against the back jaw of the pedestal. This should result in breaking more right than left frames when the right side leads, and vice versa when the left side leads.

The discussion of piston valves is not within the scope of this report, and the subject is alluded to only on account of the apparent difficulty of providing adequate relief from the presence of water. It is therefore thought pertinent to suggest that perhaps this side of the question should be given more care and attention than it has received heretofore.

The experience of two large roads, as reported to your committee, is quite significant. Each refers to a class of locomotives similar in every particular, except that a portion of each class have double front rails and slide valves, while the balance are equipped with single front rails and piston valves. The report states that all the frame failures with these locomotives are confined to the engines having single front rails and piston valves, the fractures located between the cylinder and front axle.

While it is true that no one cause for frame breakage can be given, it is safe to say that all the reasons assigned are at least contributory causes and should be taken into the account.

(As indicating what the committee considers good practice for reproduction in cast steel, a large number of frame drawings have been selected, and these are given in the report.)

The representatives of a number of steel makers examined and approved the frame designs accompanying this report, and also held independent meetings, agreeing on the following specifications:

SPECIFICATIONS FOR CAST-STEEL LOCOMOTIVE FRAMES.

Material:

| | |
|---|---|
| Acid open-hearth steel | .28 carbon. .05 phosphorus. .05 sulphur. .60 manganese. |
| Frames will be rejected that show less than .20 or over | .35 carbon. .06 phosphorus. 06 sulphur. 70 manganese. |

Tensile strength per square inch not less than 55,000 lbs.
Elongation in 2 ins. not less than 15 per cent.
All frames to be annealed.

Relating to the method of manufacture, a member contributes as follows:

"It may be well to determine whether or not the cast-steel manufacturers are all casting their frames in a manner to secure the best possible results. The method of casting, location of gates and headers, all have a very important part upon the life of the frame. It is the usual practice to cast the frame on an incline, the front end of the frame being at the top, the metal being poured into a riser at the back end of the frame, which is at the lowest point. This method results in washing the dirt and gases to the front end of the frame, and we have defective metal at the point at which the frames are most prone to break. It would therefore seem desirable to reverse this method and mold the frame so that the front end is at the lowest point and pour them through a gate leading into the two front rails. It would also seem inadvisable to place the riser at the point of the juncture of the pedestal leg to the top rail, so as to avoid any impurities separating at this point and prevent shrinkage cracks due to the different rates of cooling of the risers and of the frame section proper. It would no doubt be an improvement to locate the riser on the pedestal at a point between the tip and bottom rail.

"It seems that these points have as much bearing upon the life of the frame as the care that all the steel foundries exercise in using a high grade of material and in carefully annealing their castings.

"Relative cost of iron and steel frames: It may be advisable to state the relative cost of a finished iron or steel frame. In addition to the first cost, there is a certain amount of smith-shop work that must be done upon a steel frame before it can be bolted to the planer. By care in the steel foundries this can no doubt be reduced to a very low figure, but at present they do not exercise sufficient care to keep this expense within reasonable bounds.

"The cost of machining is also higher for steel frames, so that there is less difference between the final cost of the iron and the steel frame than the first cost would lead one to suspect."

Your committee considers cast steel a better material for locomotive frames than wrought iron.

The tensile strength of the steel suitable for frames is about 75,000 lbs. per square inch, as compared with 53,000 to 54,000 lbs. per square inch for the best hammered iron.

The cast-steel frame is practically homogeneous; that is to say, there are no welds, and it is of a uniform texture throughout its entire length.

The number of projections required for the reception of brake work, tumbling shafts, rocker pins, etc., seriously complicates the production of modern frames in hammered iron, whereas the reverse is true in the manufacture of cast-steel frames.

Generally speaking, steel is intrinsically superior to wrought iron, and all the difficulties experienced with cast steel are mainly chargeable to either design or method of manufacture, and not to the steel *per se*.

To abandon steel for such reasons is a reflection on our engineering skill and manufacturing abilities. Therefore we should devote our time and skill to the improvement of the art, and thereby approximate more nearly the possible theoretical advantages.

The following points are offered, the observation of which your committee hopes will go a great way toward mitigating the evil:

1. Sensible design.
2. Material, cast steel, made to a rational specification; careful foundry manipulation, adequate and suitable annealing.
3. Provide such form of bracing as will prevent "weaving." By weaving is meant a movement of one side independently of the other, or of the separate parts or joints with reference to each other locally, as *per contra* a movement of the frames as a whole, in unison. The bracing should be so designed that the bending, if any, should be synchronous as referred to the connected parts.
4. The clip form of pedestal binder preferred to the thimble and bolt type.
5. Provision for quickly and adequately draining cylinders. This point is just as important with slide as with piston valves.
6. Frames with single front rails should be made stronger and means provided to stiffen same back of cylinders or between cylinders and front driver.

It would seem from a study of the replies that, for the present at least, there is an intimation that the double front rail type is stronger, *per se*, and stiffer in a vertical direction, and yet as flexible longitudinally as the single front rail form; yet this conclusion is offered with hesitation, owing to the obscurity of the evidence. It is given, however, with the hope of provoking discussion or leading to special investigation.

The great success and satisfaction foreign roads are having with the so-called plate or girder form of frame, considered in the light of their conditions—and they have used both bar and plate frames—give us just a hint or suggestion that perhaps we may have something to gain by looking into this design a bit when scheming on future improvements.

## VARIABLE-SPEED MOTORS.

A PAPER BY C. A. SELEY.

During the convention of 1903, in the discussion of the committee report of electrically-driven shops, the matter of varying speed of motors by field control was debated, but left in a somewhat uncertain state by reason of lack of data.

The writer promised, if given the opportunity, to present to this association the results of tests made on machines driven by individual motors on a two and three-wire direct-current system as developed at the East Moline shop of the Rock Island System. Very complete tests of all motors and controllers have been made at these shops and certain typical ones are selected for this report.

The tests were made by Mr. S. B. Seaman, of the G. E. Co., and Mr. C. H. True, assistant superintendent of shops, to whom I am indebted for the data. The variable-speed motors at these shops may be subdivided into four types, namely:

I. Variable-speed motors having a controller to operate on a three-wire system, enabling the machine-hand to operate the motor on either of the two voltages. Further speed variation is obtained on each voltage by introducing or cutting out resistance coils in series with the motor field. This motor field is always across the outside wires of the three-wire system, and therefore, on the maximum obtainable voltage. The rheostat governing the field current is operated through the controller.

II. Variable-speed motors having a controller to operate on a two-wire system. Speed variation is obtained by means of a bank of resistance coils in series with the motor field, and operated through the controller.

III. Variable-speed motors having separated starting boxes with an auxiliary rheostat in the field circuit and operated by a hand wheel.

IV. Variable-speed motors having a reversible controller similar to those in use in street-car service and to reverse the direction of motion of the motor when desired.

Type I is used on boring mills, slotters, driving wheel and engine lathes. Type II is used on car-wheel borer and car and truck-wheel tire-turning lathes. Type III is used on planers and cylinder-boring machines. Type IV is used on bending rolls.

The following tests were made on motors on the various tools mentioned above, each being tabulated, giving the kind of machine, class of work and the electrical horse-power.

Tests 1 to 6 were made on motors of Type I. Column 1 shows the position of the rheostat arm. There are for each voltage sixteen successive steps, giving sixteen different speeds on each voltage. These positions are given by numbers indicating the number of contacts from the O point to where the rheostat arm is set. Column 2 gives the field current and column 3 the armature current. Column 4 gives the armature voltage, which is about 115 volts over the first range of speed, and 230 volts over the second. Column 5 gives the electrical horse-power delivered to the motor. Column 6 gives the cutting speed in feet per minute.

Tests 7 and 8 are of motors of Type II, and tests 9 to 11 are of motors of Type III. Test 12 is of a group of tools on a motor-driven line shaft.

TEST 1.—69-IN. DRIVING WHEEL LATHE, TURNING 62½-IN. TIRES; MOTOR TYPE CK. 8-15-150/600.

| Rheo. stat. | Field Amps. | Armature. Amps. | Armature. Volts. | Elec. H.P. | Cutting Speed. F.P.M. | Remarks. |
|---|---|---|---|---|---|---|
| 00 | 5.55 | 5 | 118 | 1.6 | .... | |
| 0 | 4.70 | 22 | 104 | .. | 7.5 | |
| 3 | 4.00 | 23 | 116 | 4.0 | 8.0 | |
| 4 | 3.90 | 23 | 116 | .. | .... | |
| 5 | 3.30 | 26 | 116 | .. | .... | |
| 6 | 3.10 | 25 | 116 | .. | .... | Motor running light. |
| 7 | 2.90 | 27 | 116 | 5.1 | .... | Two chips, 3-16 x ¼ |
| 9 | 2.90 | 25 | 116 | .. | .... | deep x .089 per rev. |
| 10 | 2.45 | 26 | 116 | .. | .... | |
| 11 | 2.20 | 30 | 116 | 5.3 | .... | |
| 12 | 1.95 | 30 | 116 | .. | 11.45 | |
| 14 | 1.95 | 30 | 115 | .. | .... | |
| **16** | **1.50** | **38** | **113** | **6.3** | **12.90** | |
| 0 | 4.60 | 36 | 230 | 12.5 | 14.60 | |

TEST 2.—SPEED VARIATION, WHEEL LATHE WITHOUT LOAD.

| Rheostat. | Field Amperes. | Volts. | R. P. M. |
|---|---|---|---|
| Off. | 3.00 | 114 | 0 |
| 1 | 5.55 | 114 | 150 |
| 2 | 4.80 | 113 | 158 |
| 3 | 4.15 | 113 | 165 |
| 4 | 3.75 | 113 | 170 |
| 5 | 3.25 | 113 | 175 |
| 6 | 3.00 | 112 | 185 |
| 7 | 2.75 | 111 | 195 |
| 8 | 2.50 | 114 | 205 |
| 9 | 2.30 | 113 | 215 |
| 10 | 2.15 | 114 | 225 |
| 11 | 2.00 | 113 | 230 |
| 12 | 1.90 | 113 | 240 |
| 13 | 1.80 | 113 | 250 |
| 14 | 1.70 | 113 | 265 |
| 15 | 1.60 | 114 | 275 |
| 16 | 1.55 | 114 | 295 |
| 1 | 5.45 | 227 | 290 |
| 16 | 1.55 | 227 | 630 |

TEST 3.—18-INCH SLOTTER; MOTOR, TYPE CK. 8-15-150/600.

| Rheostat. | Amperes. | Volts. | El. H. P. | Remarks. |
|---|---|---|---|---|
| 3 | 1 to 10 | 115 | 1.4 | Chip 5-16 x 3-64. |
| 8 | 1 to 24 | 115 | 3.7 | Chip ⅝ x 3-64. |
| 8 | 1 to 30 | 115 | 4.6 | Chip ¾ x 3-64. |
| 12 | 1 to 28 | 115 | 4.3 | Chip ½ x 3-64. |
| 16 | 4 to 10 | 115 | 1.4 | Chip 1-16 x 3-64. |

Slotter was making 2 cycles on the 12th point of rheostat on work about 5 inches deep.

TEST 4.—72-INCH BORING MILL, BORING STEEL TIRE, 52 INCHES INSIDE DIAMETER; MOTOR, TYPE CK. 6-10-275/1000.

| Amperes. | Volts. | El. H. P. | Cut F. P. M. | Remarks. |
|---|---|---|---|---|
| 17 | 115 | 2.6 | 17.7 | |
| 23 | 115 | 3.1 | 18.5 | |
| 26 | 115 | 3.5 | 18.5 | |
| 30 | 115 | 4.0 | 19.4 | One chip ¼ x 3-64. |
| 33 | 115 | 4.4 | 20.4 | One chip 3-16 x 3-64. |
| 39 | 115 | 5.2 | 22.2 | Chips of dark blue. |

The following readings were taken at intervals of approximately three seconds:

| | | | | |
|---|---|---|---|---|
| 44 | 115 | ... | 22 | |
| 48 | 115 | 4.8 | 22 | Two chips, ¼ x 3-32 each. |
| 37 | 115 | ... | 22 | Cutting tools would not |
| 39 | 115 | ... | 22 | stand up under this work. |
| 38 | 115 | ... | 22 | Although there was an exces- |
| 52 | 115 | ... | 22 | sive ampere overload there |
| 50 | 115 | ... | 22 | was no sparking or heating |
| 50 | 115 | ... | 22 | at any point about the motor. |
| 48 | 115 | ... | 22 | |
| 49 | 115 | ... | 22 | |

TEST 5.—DRIVING AXLE LATHE; MOTOR, TYPE CK. 8-15-150/600.

| Rheo. stat. | Field Amps. | Arm. Amps. | Volts. | El. H. P. | Cut F. P. M. | Remarks. |
|---|---|---|---|---|---|---|
| 0 | 5 | 29 | 114 | 5.9 | 17 | Two cuts on 8-in. |
| 2 | .. | 31 | 112 | ... | .. | axle, 3-16 x 5-64. |
| 3 | 4 | 32 | 111 | ... | .. | |
| 4 | 3.9 | 33 | 112 | 6.15 | .. | |
| 5 | 3.3 | 35 | 112 | ... | .. | |
| 6 | 3.1 | 36 | 112 | ... | 18.7 | |
| 7 | 2.9 | 39 | 112 | 6.85 | .. | |
| 8 | 2.8 | 42 | 112 | ... | .. | |
| 9 | 2.6 | 44 | 112 | ... | 21.9 | |
| 10 | 2.4 | 47 | 114 | 8.0 | .. | |
| 11 | 2.2 | 48 | 116 | ... | .. | |
| 12 | 1.9 | 52 | 118 | 8.7 | 25 | |

Did not get over on to 230-volt side.

TEST 6.—36-IN. TRIPLE-GEARED LATHE; MOTOR, TYPE CE. 8-5-400/1600.

| Rheo. stat. | Arm. Amps. | Volts. | El. H. P. | Cut F. P. M. | Remarks. |
|---|---|---|---|---|---|
| 0 | 1 | 117 | .5 | .. | Motor light. |
| 0 | 10 | 117 | 1.5 | 42 | Back gear in with heavy cut, cast iron, 11 ins. diam. |
| 0 | 22 | 117 | 3.5 | 42 | Back gear in, light. |
| 4 | 1.5 | 118 | .7 | 48 | Back gear in with |
| 4 | 8 | 118 | 1.3 | 48 | heavy cut, cast |
| 4 | 23 | 118 | 3.7 | 48 | iron, 11 ins. diam. |
| 4 | 30 | 118 | 4.9 | 48 | |
| 4 | 40 | 117 | 6.3 | 48 | |

TEST 7.—42-IN. STEEL-TIRE LATHE; MOTOR, TYPE CE. 6-10-550/1100.

| Rheo. stat. | Field Amps. | Arm. Amps. | Volts. | El. H. P. | Cut in F. P. M. | Remarks. |
|---|---|---|---|---|---|---|
| 0 | 3 | 7 | 236 | 3.1 | ... | Lathe running light. |
| 0 | 3 | 12 | 229 | 4.7 | 9.6 | Starting two cuts 30-in. wheels, 3-32-in. feed. |
| 4 | 1.9 | 13 | 231 | 4.6 | 15 | 2 cuts, 3-32 x 3-32. |
| 5 | 1.75 | 23 | 231 | 5.5 | 15.2 | 2 cuts, 3-16 x 3-32. |
| 6 | 1.42 | 30 | 230 | 9.7 | 15.7 | 2 cuts, 3-16 x 3-32. |
| 8 | 1 | 34 | 230 | 10.7 | 16.1 | 2 cuts, ¼ x 3-32. |
| 10 | 1 | 36 | 229 | 11.3 | 17.2 | 2 cuts, ¼ x 3-32. |
| 12 | 1 | 38 | 230 | 12 | 21.8 | 2 cuts, ¼ x 3-32. |

TEST 8.—SPEED VARIATION, 42-IN. STEEL-TIRE LATHE WITHOUT LOAD.

| Rheostat. | Field Amperes. | Volts. | Spindle R.P.M. |
|---|---|---|---|
| 1 | 3.00 | 230 | 1.22 |
| 2 | 2.55 | 230 | 1.33 |
| 3 | 2.20 | 230 | 1.43 |
| 4 | 1.95 | 230 | 1.53 |
| 5 | 1.75 | 230 | 1.62 |
| 6 | 1.62 | 230 | 1.62 |
| 7 | 1.45 | 230 | 1.66 |
| 8 | 1.35 | 230 | 1.71 |
| 9 | 1.25 | 230 | 1.81 |
| 10 | 1.25 | 230 | 1.87 |
| 11 | 1.15 | 230 | 1.93 |
| 12 | 1.12 | 230 | 2.00 |
| 13 | 1.05 | 230 | 2.20 |
| 14 | 1.00 | 230 | 2.40 |
| 15 | .95 | 230 | 2.50 |

TEST 9.—SPECIAL ROD PLANER; MOTOR, TYPE CK. 8-15-275/550.

| Rheo-stat. | Field Amps. | Arm. Amps. | Volts. | El. H.P. | Cut in F.P.M. | Remarks. |
|---|---|---|---|---|---|---|
| 0 | 4.8 | 5 | 227 | 3 | .. | Planer running light |
| 0 | 4.8 | 20 | 225 | 7.5 | 17 | 2 cuts, 3-16 x .083. |
| 2 | 3.1 | 21 | 224 | 7.2 | 20 | Cutting. |
| 2 | 3.1 | 6 | 224 | .. | .. | Returning. |
| 3 | 2.2 | 25 | 225 | 8.2 | 24 | Cutting. |
| 3 | 2.2 | 5 | 225 | .. | .. | Returning. |
| 4 | 1.8 | 30 | 228 | 9.7 | 28 | Cutting. |
| 4 | 1.8 | 6 | 228 | .. | .. | Returning. |
| 5 | 1.5 | 32 | 226 | 10.1 | 32 | Cutting. |
| 5 | 1.5 | 9 | 226 | .. | .. | Returning. |
| 6 | 1.2 | 36 | 225 | 11.2 | 35 | Cutting. |
| 6 | 1.2 | 10 | 225 | .. | .. | Returning. |
| 7 | 1.1 | 36 | 226 | 11.2 | 38 | Cutting. |
| 7 | 1.1 | 11 | 226 | .. | .. | Returning. |
| 8 | 1. | 36 | 224 | 11.1 | 40 | Cutting. |
| 8 | 1. | 12 | 224 | .. | .. | Returning. |
| 9 | .85 | 44 | 225 | 13.5 | 45 | Cutting. |
| 9 | .85 | 16 | 225 | .. | .. | Returning. |

This planer has done work on babbitt metal at the rate of 70 feet per minute, the motor running cool and sparkless at 1,300 R.P.M., although the maximum rated R.P.M. is but 550.

TEST 10.—48 BY 48 BY 6 PLANER; MOTOR, TYPE CK. 8-15-275/550.

| Rheo-stat. | Field Amps. | Arm. Amps. | Volts. | El. H.P. | Cut in F.P.M. | Remarks. |
|---|---|---|---|---|---|---|
| 0 | 4.8 | 12 | 224 | 5 | .. | Cutting 7-16 x 1-32 C. I. |
| 0 | 4.8 | 14 | 224 | 5.7 | .. | Returning. |
| 6 | 1.2 | 12 | 224 | .. | 18 | Cutting. |
| 6 | 1.2 | 14 | 224 | .. | .. | Returning. |
| 10 | 1 | 13 | 224 | .. | 22.5 | Cutting. |
| 10 | 1 | 14 | 224 | .. | .. | Returning. |
| 14 | .8 | 18 | 224 | 5.7 | .. | Cutting. |
| 14 | .. | 20 | 224 | 6.3 | .. | Returning. |
| 15 | .8 | 20 | 224 | .. | .. | Cutting. |
| 15 | .. | 21 | 224 | .. | .. | Returning. |
| 16 | .75 | 26 | 224 | 7.9 | .. | Cutting. |
| 16 | .. | 28 | 224 | 8.5 | .. | Returning. |

In order to show the variation in load on the motor, the following readings were taken on one point of the rheostat:

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | .. | 12 | 224 | 5 | .. | Bed returning. |
| .. | .. | 32 | 224 | 9.6 | .. | Reversing to cut. |
| .. | .. | 14.5 | 224 | 5.7 | .. | Cutting. |
| .. | .. | 54 | 224 | 15.6 | .. | Reversing from cut. |
| .. | .. | 12 | 224 | 5 | .. | Returning. |

TEST 11.—54 BY 54 BY 34 FRAME PLANER; MOTOR, TYPE CL. 6-20-375/750.

| Rheo-stat. | Field Amps. | Arm. Amps. | Volts. | El. H.P. | Cut in F.P.M. | Remarks. |
|---|---|---|---|---|---|---|
| 0 | 5.6 | 12 | 230 | 5.4 | 12.8 | Planer running light |
| 0 | 5.6 | 18 | 228 | 7.2 | .. | Returning. |
| 4 | 2.7 | 12 | 230 | .. | 16.75 | Two cuts ⅜ x 5-32 C. I. |
| 4 | .. | 18 | 232 | .. | .. | |
| 8 | 1.6 | 14 | 230 | .. | 22.6 | |
| 8 | .. | 20 | 232 | .. | .. | |
| 12 | 1.1 | 18 | 230 | .. | 28 | |
| 12 | .. | 24 | 232 | .. | .. | |
| 16 | .. | 28 | 230 | 8.9 | .. | |
| 16 | .82 | 22 | 230 | 7 | 31.4 | |

In order to show the variation in load on the motor, the following readings were taken on the 12th point of the rheostat:

| | | | | | | |
|---|---|---|---|---|---|---|
| 12 | 1.1 | 24 | 230 | 7.7 | 28 | Cutting. |
| .. | 1.1 | 56 | 230 | 17.6 | .. | At reverse from cut |
| .. | 1.1 | 22 | 230 | .. | .. | Returning. |
| .. | 1.1 | 30 | 230 | 9.5 | .. | Reversing to cut. |

TEST 12.—The following test was made on a motor driving a group of machines in a toolroom. These tools were added one at a time after readings had been taken on the power required for the motor alone, motor and line shaft, and also with the countershafting. The final reading is the total power required, but it is not generally the case that all of the tools of a group are running full at one time:

MOTOR, 15 H.P.; SEMI-ENCLOSED, CONSTANT SPEED, SHUNT WOUND, SILENT CHAIN DRIVE, SHORT CENTERS.

| Reading. | Amps. | Volts. | El. H. P. | Remarks. |
|---|---|---|---|---|
| 1 | 5 | 235 | 1.6 | Motor running light. |
| 2 | 6 | 238 | 1.9 | Motor running line shaft. |
| 3 | 11 | 226 | 3.3 | Motor, line and counters of following tools. |
| 4 | 12 | 225 | 3.6 | No. 3 LeB. milling machine fluting tap. |
| 5 | 13 | 227 | 3.95 | No. 3 LeB milling machine fluting reamer. |
| 6 | 18 | 226 | 5.4 | 24 x 24 Planer at reversing point. |
| 7 | 20 | 227 | 6.1 | 14-inch lathe, boring 1⅜-inch hole. |
| 8 | 26 | 228 | 7.0 | 10-inch lathe, 1-16 cut. |
| 9 | 26 | 229 | 7.9 | 14-inch lathe running to capacity. |
| 10 | 30 | 229 | 9.2 | 21-inch drill press drilling 1-inch hole in steel. |
| 11 | 37 | 228 | 11.3 | Tool dresser. |
| 12 | 38 | 228 | 11.6 | Power hack saw. |
| 13 | 44 | 227 | 13.4 | Two aut. tool grinders. |

## BOILER DESIGNS.

COMMITTEE: D. VAN ALSTYNE, W. F. M. GOSS, C. E. FULLER, H. T. BENTLEY, O. H. REYNOLDS.

With reference to the location of water glass and gauge cocks, we recommend that the lowest visible part of the water glass and lowest gauge cock be not less than 3 ins. above the highest point of the crown sheet for curved and flat crown sheets, and that the water glass and gauge cocks be as near the vertical center line of the boiler as they can be conveniently located without having the gauge cocks out of reach of the engineer. We also recommend 8 ins. of exposed length of water glass and three gauge cocks with vertical spacing of 3-in. centers.

Replies indicate that crown sheets, sloped ⅝ in. per foot, represent very general practice, and that this slope has proved satisfactory.

For various reasons given, an automatic low-water detector seems not to be a desirable attachment to locomotive boilers.

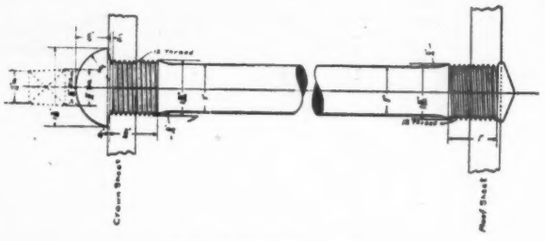
Regarding the best form of radial stays, the design shown in the accompanying engraving appears to be general practice, and is recommended.

In order to obtain information as to the temperatures inside a boiler as related to leaky flues and burned side sheets, the committee made temperature tests with fusible metal in the water

leg, between the flues and inside flues plugged up. The results are given in Tables I and VI inclusive. While the tests show temperatures considerably above saturated steam temperatures in most cases, the committee has concluded that the method of determining temperatures by means of fusible metal is not satisfactory, and believes that temperatures should be determined by more delicate means, such as the thermopile, and that such determinations should be as numerous as possible in order to trace the direction of circulation in the boiler. On the other hand, it is quite possible that the very high temperatures which are probably required to destroy sheets and cause leaky flues are confined to the sheets themselves, and that little if any higher temperatures exist in the water than have already been found by the fusible metal tests.

This point is one which, so far as we know, is definitely determined, although it has been proven that the temperature of the sheet approaches much more closely that of the water than that of the heated gases. It is essential that the circulation within the boiler shall follow such lines and proceed with such regularity that solid water many overlie all portions of the heating surface.

Since circulation is due to the excess of weight of a comparatively cool column of water over a hotter and lighter body, or a mixture of hotter water and steam, the design of boiler which least impedes the flow due to this head will permit of the most rapid circulation, and hence, most rapid carrying away of heat from sheets. It would follow also that the greater the depth of boiler the greater the head to produce circulation at the point where most needed, namely, just above the fire line.



BOILER CROWN STAY.

It would appear that for a given boiler there is a maximum allowable steam generation without injury to the sheets, determined by a maximum possible circulation in that particular boiler.

Through the courtesy of Mr. F. H. Clark, superintendent motive power, Chicago, Burlington & Quincy Railway, the committee is permitted to present the results of experiments made to determine the temperature of the water in various portions of the boiler when the locomotive is standing, no steam being used from the boiler excepting as required to supply the injector. The results of these experiments indicate that when the feed is delivered in the usual manner to the boiler, the water in the water-leg on the opposite side may have a temperature 100 degrees less than the normal temperature of the boiler, and that the intermixing is greatly improved by using a perforated pipe extending beyond the check within the boiler either longitudinally or transversely, and, also, by the omission of a pipe but by means of an orifice which opens upward. In the progress of the tests it was found also that when the intermixing was most complete the drop in steam pressure was greatest, so that it may almost be said that the degree of intermixing in any given boiler may be judged by noting the rapidity with which the steam pressure falls under the action of the injectors when the locomotive is at rest. The details of these tests and of the results obtained from them are given in Appendix 3.

Recognizing the difficulty of getting conclusive information from road tests we recommend that laboratory tests be made for the purpose of determining the rapidity of circulation in a boiler generating varying amounts of steam up to its maximum, and also for determining temperatures in the sheets where the greatest trouble is experienced.

## SUBJECTS FOR 1905.

COMMITTEE—H. BARTLETT, J. F. DEEMS, A. W. GIBBS.

COMMITTEE WORK.

1. Motive-Power Terminals.—What can and should be done to reduce locomotive terminals to the basis of a machine for treating and handling engines, apart from the question of housing, the object being prompt handling of power, greater efficiency in service and less detention at terminals, while affording more time and better facilities for care and repair of engines.

2. The best practice in ashpan construction, with special reference to wide-firebox engines having trailing wheels—consideration to embrace best design of trailing-wheel arrangement.

3. Merits of the balanced compound locomotive.

4. Investigation of design and material for locomotive fronts and front doors, with a view to affording relief from leaky front ends.

5. Investigation of the subject of staybolts—committee to consider the material, iron, bronze and copper, as well as the form of the bolt under the conditions and temperatures met in service.

6. Modification in design of wide fireboxes of locomotives, with a view of limiting injury in case of low water, committee to consider the question of fusible plugs, as to number, location and size, and also the application of water-circulating pipes from throat to crown sheet, and other devices which will localize the damage.

7. The practicability of water-softening for locomotive use by means of chemicals or the application of heat, and the maximum cost per 1,000 gals. permissible, that the expenditure could be recovered in reduced motive-power expenses.

8. The value of superheated steam for locomotive work.

9. The advisability of a 4-4-2 Atlantic type locomotive for light passenger service and a 4-6-2 locomotive for fast freight service.

10. Committee appointed to act as an advisory committee to the Pennsylvania Railroad Company with reference to the locomotive-testing plant at St. Louis fair to present to Master Mechanics' Association summarized statement of important results which are obtained.

11. Best method of heating and ventilating roundhouses.

12. Best method of fire protection for railroad shops.

INDIVIDUAL PAPERS.

1. The strict observance of the Golden Rule in management of workshops.

2. The most efficient organization for mechanical department.

3. The average engine hours locomotives are in service, in shop under repairs, or waiting to get in shop, per annum, and the percentage of total time locomotives are actually in and out of service per annum.

4. Shop layouts for roads having 350, 500, 750 and 1,000 locomotives.

## COST OF LOCOMOTIVE REPAIR SHOPS.

COMMITTEE—R. H. SOULE, L. R. POMEROY, T. H. CURTIS, S. F. PRINCE, A. E. MANCHESTER.

Your Committee on Cost of Locomotive Repair Shops submits, in tabulated form, figures obtained from members; as much data relating to the cost of car-shop buildings was returned, it has been included in the statements.

In selecting units on which to base cost figures the square foot and the cubic foot have generally been used for buildings; in power plants the engine horse-power, boiler horse-power and generator kilowatts have also been used; in roundhouses the stall has been taken as the proper unit.

In computing the square feet of buildings the outside dimensions have been used (giving the ground area covered); in computing the cubic feet of buildings the average external height has been taken (giving the total volume occupied).

The circular of inquiry sent out by the committee contained the following clause:

"The committee will treat the data confidentially and use them only in the determination of units, averages, etc., which will be embodied in its report to the association; in no case will the committee publish the name of the railroad, or the locality, or the officer giving the data."

It was foreseen that such a stipulation was necessary in order to secure any data; and in the figures which follow, the different items are identified by reference numbers only, with such explanatory notes added as will aid in interpreting the unit prices; shops built prior to 1895 are designated as "old," those built since 1895 as "modern"; in a few cases the notes are based on uncertain information and are followed by an interrogation mark (?).

POWER PLANTS.—BUILDINGS ONLY (WITHOUT CONTENTS).

| Item. | Cost per Sq. Ft. | Cost per Cu. Ft. | Notes. |
|---|---|---|---|
| 1 | 2.14 | .076 | Far West, modern, brick and concrete, with steel frame roof. |
| 2 | 2.25 | .057 | Middle West, modern; brick and steel, fireproof, basement under engine room. |
| 3 | 2.45 | .060 | East modern; brick and steel with roof of tile and cement, the whole thoroughly fireproof, a very fine and somewhat ornate building. |
| 4 | 1.71 | .064 | Middle West, old; brick and steel with shingle roof. |
| 5 | 3.50 | .... | Southeast, modern; brick and steel, building relatively long and narrow, increasing ratio of wall area to floor area; very deep and heavy foundations, coal trestle inside of boiler room. (These figures should be used with caution as they are not official, but were taken from a published statement.) |
| 6 | 4.20 | .130 | Middle West, modern; brick and steel, a very large plant, has two small wings which increase the ratio of wall area to floor area; basement under whole of engine room and about half of boiler room; interior finish highly ornamental. |
| 7 | 2.42 | .071 | Middle West, modern; brick and steel, low (on account of locomotive boilers), no basement, only pits. |
| 8 | 6.48 | .138 | Middle West, modern; brick and steel, basement throughout, overhead coal bunkers, fireproof, considerable architectural ornamentation. |
| 9 | 3.32 | .083 | Middle West, modern; brick and steel, fireproof. |
| 10 | 2.83 | .157 | East, modern; concrete construction including the roof, low building, basement under the engine room only. |
| 11 | 2.85 | .084 | Middle West, modern; brick and steel, basement under part of engine room only. |
| 12 | 3.15 | .120 | West, modern; brick and steel. |

POWER PLANTS.—BOILERS.

With Settings (except where noted).

| Item. | Cost per B. H. P. | Notes. |
|---|---|---|
| 13 | 11.70 | Marine type internally fired. |
| 14 | 13.64 | Horizontal tubular, bricked in. |
| 15 | 10.64 | Water tube. |
| 16 | 11.02 | Water tube. |

| | | |
|---|---|---|
| 17 | 20.40 | Vertical water tube, bricked in and including automatic stokers, stoker engines, stoker engine piping, fan engine and piping, feed pumps and piping. |
| 18 | 13.09 | Horizontal water tube with superheater. |
| 19 | 12.00 | Horizontal return tube, boilers in units of 100 horse-power. |
| 20 | 17.39 | Horizontal water tube boilers in 300 horse-power units; automatic stokers included. |
| 21 | 12.84 | Horizontal fire tube. |
| 22 | 8.44 | Horizontal water tube; without settings. |
| 23 | 15.35 | Water tube, including automatic stokers. |
| 24 | 19.25 | Horizontal water tube; closed ash pit for forced draft. |
| 25 | 13.25 | Horizontal water tube in 275 horse-power units. |
| 26 | 14.45 | Horizontal water tube, includes feed-water heater and feed pumps. |
| 27 | 6.50 | Plain horizontal, brick set. |
| 28 | 11.87 | Vertical water tube in 300 horse-power units. |

POWER PLANTS.—MECHANICAL STOKERS.

| ITEM. | COST PER B. H. P. | NOTES. |
|---|---|---|
| 29 | 4.48 | Chain grate. |
| 30 | 3.09 | |

POWER PLANTS.—COAL AND ASH HANDLING APPARATUS.

| ITEM. | COST PER B. H. P. | NOTES. |
|---|---|---|
| 31 | 4.46 | Wooden trestle 12 feet high, with sloping bottom (for shooting coal into boiler room), and necessary incline approach. |
| 32 | 4.75 | Power conveyor for coal and ashes. |
| 33 | 2.14 | Coal handling apparatus, simply gravity hoppers and push cars; ash handling apparatus, buckets handled by electric telpher. |
| 34 | 6.16 | Includes coal conveyor from basement to roof, and separate ash conveyor; also a separate ash house with connecting tunnel, elevator, bin, etc. |
| 35 | 5.30 | Based on ultimate boiler horsepower capacity of the plant. |
| 36 | 3.42 | Includes crusher, conveyors, elevators, etc. |
| 37 | 1.73 | Designed large enough to take care of an eventual one-third increase in boiler capacity. |

POWER PLANTS.—MECHANICAL DRAFT APPARATUS.

| ITEM. | COST PER B. H. P. | NOTES. |
|---|---|---|
| 38 | 1.30 | Based on ultimate boiler horse-power capacity of the plant; includes stack 7 feet 8 inches diameter, by 60 feet high. |
| 39 | 1.45 | Includes small sheet-iron stack 5 feet diameter and 25 feet high. |
| 40 | 2.74 | Induced draft, stack extends five feet above roof. |
| 41 | 1.50 | |

POWER PLANTS.—ECONOMIZERS.

| ITEM. | COST PER B. H. P. | NOTES. |
|---|---|---|
| 42 | 2.33 | Based on ultimate boiler horse-power capacity of plant; includes setting, bricking in, etc., complete. |
| 43 | 3.75 | Quoted by E. B. Katte (Electrical Engineer N. Y. C. & H. R. R. R.), in paper entitled "An Economizer Discussion," read at the November, 1903, meeting of the New York Railroad Club, as representing cost of economizers completely erected in New York city; this estimate is based on 3.25 square feet of economizer tube heating surface to each boiler horse-power. |
| 44 | 5.40 | Quoted by Henry G. Meyer, Jr., in his book "Steam Power Plants," Chap. VIII, p. 118, as representing cost of economizers (for plants of 1,000 boiler horse-power or over) erected, bricked in and connected, ready for use; this estimate is based on 4.8 square feet of economizer tube heating surface to each boiler horse-power. |

POWER PLANTS.—FEED PUMPS.

| ITEM. | COST PER B. H. P. | NOTES. |
|---|---|---|
| 45 | 1.96 | Outside central packed, double plunger. |
| 46 | 2.66 | |

POWER PLANTS.—FEED-WATER HEATERS.

| ITEM. | COST PER B. H. P. | NOTES. |
|---|---|---|
| 47 | 1.28 | Open type. |
| 48 | .96 | Vertical, 48 inches diameter by 9 feet 10 inches high. |
| 49 | .50 | Open type. |
| 50 | .60 | Vertical. |

POWER PLANTS.—ENGINES DRIVING GENERATORS ONLY.

| ITEM. | COST PER H. P. | NOTES. |
|---|---|---|
| 51 | 24.80 | Horizontal, simple. |
| 52 | 12.90 | Horizontal cross compound, in 300 horse-power units. |
| 53 | 12.15 | One large horizontal Corliss, and one small high-high-speed, both simple. |
| 54 | 19.34 | Horizontal cross compound in 600 horse-power units. |
| 55 | 6.66 | Horizontal, simple. (?) |
| 56 | 12.00 | Horizontal cross-compound in several units of different sizes. |
| 57 | 17.62 | Average quotations of twenty-six bidders on 350 horse-power compound engines, and nineteen bidders on 225 kilowatts generators for municipal electric light plant at Jamestown, New York, see *Engineering News* (Supplement), of February 11, 1904. |
| 58 | 10.49 | Horizontal cross-compound, in units of 650 horse-power and less. |
| 59 | 21.45 | Vertical compound non-condensing engines in units of 250 horse-power. |
| 60 | 16.40 | Extra strong frames and parts, to stand when necessary very heavy load, in units of 175 horse-power. |
| 61 | 16.00 | Vertical compound non-condensing, in 250 horse-power units. |
| 62 | 13.60 | Part horizontal cross-compound condensing, part vertical compound condensing. |
| 63 | 11.70 | Horizontal tandem compound. |

POWER PLANTS.—ENGINES NOT DRIVING GENERATORS.

| ITEM. | COST PER H. P. | NOTES. |
|---|---|---|
| 64 | 12.80 | Horizontal, simple. |
| 65 | 8.25 | Horizontal Corliss in a 350 horse-power unit. |
| 66 | 8.28 | Plain horizontal engine without refinements. |

POWER PLANTS.—ENGINES AND GENERATORS DIRECT CONNECTED.

| ITEM. | COST PER H. P. | COST PER K. W. | NOTES. |
|---|---|---|---|
| 67 | 36.28 | 60.64 | Simple vertical 250 horse-power engines with engine type 150 kilowatts generators. |

POWER PLANTS.—CONDENSERS.

| ITEM. | ENGINE COST PER H. P. | NOTES. |
|---|---|---|
| 68 | 5.70 | |
| 69 | 2.26 | Surface condenser; includes air pump. |

POWER PLANTS.—GENERATORS.

| ITEM. | COST PER K. W. | NOTES. |
|---|---|---|
| 70 | 28.00 | Direct current. |
| 71 | 20.21 | Direct current in 200 kilowatts and 110 kilowatts units. |
| 72 | 22.89 | Direct current in 200 kilowatts and 100 kilowatts units. |
| 73 | 32.58 | Generators in 400 horse-power units; includes also switchboard and station wiring. |
| 74 | 17.04 | Very small generators. |
| 75 | 17.33 | Direct current in 500 kilowatts and 250 kilowatts units. |
| 76 | 30.48 | Average quotations of twenty-six bidders on 350 horse-power compound engines, and nineteen bidders on 225 kilowatts generators for municipal electric light plant at Jamestown, N. Y., see *Engineering News* (Supplement), of February 11, 1904. |
| 77 | 17.71 | Direct current in 400 kilowatts and 75 kilowatts units. |
| 78 | 22.61 | Generators in 75 kilowatts units. |
| 79 | 19.20 | Units of 100 kilowatts direct current at 240 volts. |
| 80 | 17.40 | Units of 150 kilowatts direct current. |
| 81 | 21.10 | Units of 200 kilowatts direct current at 220 volts. |
| 82 | 20.30 | Direct current at 220 volts. |

POWER PLANTS.—SWITCHBOARDS.

| ITEM. | COST PER GENERATOR K. W. | NOTES. |
|---|---|---|
| 83 | 11.30 | One small generator, 50 kilowatts capacity. |
| 84 | 5.20 | Direct current only. |
| 85 | 3.65 | Small and simple. |
| 86 | 7.08 | Direct current only. |
| 87 | 5.33 | Direct current only. |
| 88 | 4.45 | In place, but not connected. |
| 89 | 8.33 | Direct current only. |
| 90 | 2.50 | Simple and plain, direct current only. |
| 91 | 3.50 | Direct current 220 volts. |
| 92 | 4.00 | Direct current only. |

POWER PLANTS.—AIR COMPRESSORS.

| ITEM. | COST PER 100 CU. FT. FREE AIR PER MIN. | NOTES. |
|---|---|---|
| 93 | 508.47 | Steam end simple, air end two stage. |
| 94 | 507.53 | Simple steam cylinder; compound air cylinders with inter-cooler. |
| 95 | 385.00 | One large and one small duplex cross-compound. |
| 96 | 647.00 | Steam and cross compound; air end two-stage, units, 1,500 cubic feet free air per minute. |
| 97 | 412.03 | Duplex, steam end compound, air end two-stage, capacity 1,000 cubic feet free air per minute. |
| 98 | 271.00 | Duplex, steam end compound, air end two-stage. (?) |
| 99 | 400.00 | Steam end cross-compound, air end two-stage. |
| 100 | 290.46 | Steam end simple, air end two-stage with inter-cooler, capacity 1,200 cubic feet free air per minute. |
| 101 | 372.53 | Steam end compound, air end two-stage. |
| 102 | 866.66 | Steam end compound, air end two-stage; very elaborate valve gear with refinements in cut-off, etc., capacity 1,500 cubic feet free air per minute. |
| 103 | 338.20 | Single stage air compressor subdivided into two units. |
| 104 | 370.00 | Duplex, steam end simple, air end compound with inter-cooler. |
| 105 | 682.00 | Duplex, steam end compound, air end two-stage. |
| 106 | 533.00 | Steam end simple, air end two-stage. |

### POWER PLANTS.—PIPING.

| Item. | Cost per Engine H. P. | Notes. |
|---|---|---|
| 107 | 1.64 | Connections close and short. |
| 108 | 11.67 | Includes the Holly automatic return system. |
| 109 | 7.60 | An average installation. |
| 110 | 7.75 | A most complete and well arranged installation; plant has 2,000 horse-power of boilers and 2,250 horse-power of engines; boilers are vertical, requiring a maximum amount of piping. |
| 111 | 1.94 | Small plant, with boilers, feed-water heater, engine and air compressor close together. |
| 112 | 10.93 | Plant includes economizer, induced draft apparatus, hydraulic pumps and accumulator, etc. |
| 113 | 10.88 | A very complete installation, based on rigid specifications. |
| 114 | 10.72 | Designed with a view to an eventual increase of one-third present engine horse-power. |
| 115 | 4.00 | Simple and direct. |
| 116 | 8.20 | Includes hydraulic system. |
| 117 | .88 | Short, simple and direct. |
| 118 | 3.78 | Simple and direct. |

### POWER PLANTS.—CHIMNEYS.

| Item. | Cost per B. H. P. | Notes. |
|---|---|---|
| 119 | 1.12 | Steel, 3 feet 8 inches diameter, by 80 feet high. |
| 120 | 12.62 | Hollow brick, 7 feet diameter inside, by 175 feet high. |
| 121 | 4.93 | Common brick, fire brick lining, 7 feet 3 inches inside diameter, and 140 feet high. |
| 122 | 3.19 | Hollow brick, 10 feet inside diameter and 125 feet high, supplemented by undergrate forced draft. |
| 123 | 2.47 | Square brick base 25 feet high, surmounted by steel stack 4 feet 6 inches diameter, and 75 feet high, total height 100 feet. |
| 124 | 4.25 | Circular brick chimney, diameter inside, 6 feet; height, 120 feet. |
| 125 | 6.74 | Hollow brick, 4 feet diameter and 80 feet high. |
| 126 | 3.33 | Steel, brick-lined part way up. |
| 127 | 4.51 | Designed of sufficient size to take care of one-third increase of boiler capacity. |
| 128 | 9.50 | Brick, 9 feet diameter and 188 feet 6 inches high. |
| 129 | 5.00 | Steel, 4 feet diameter and 150 feet high. |
| 130 | 4.16 | Brick. |

### POWER PLANTS—TOTAL COST.

| Item. | Cost per Engine H. P. | Cost per Generator K. W. | Cost per Sq. Ft. | Cost per Cu. Ft. |
|---|---|---|---|---|
| 131 | 131.33 | 219.00 | 11.40 | .40 |
| 132 | 140.27 | 210.00 | 7.00 | .18 |
| 133 | 115.00 | 167.00 | 12.20 | .28 |
| 134 | 185.06 | 278.00 | 11.50 | .36 |
| 135 | 129.28 | 210.60 | 14.62 | .33 |
| 136 | 123.00 | 191.00 | 14.30 | .36 |
| 137 | 129.00 | 225.00 | 10.40 | .58 |
| 138 | 90.90 | 151.50 | 10.40 | .24 |
| 139 | 128.60 | 211.00 | 10.55 | .31 |

NOTES.

131. Far West, modern; a substantial, effective plant devoid of ornamentation or refinements; coal dumped from trestle and shoveled, ashes shoveled.

132. Middle West, modern; building has considerable ornamentation inside and out, but the equipment auxiliaries are simple, overhead crane in engine room.

133. East, modern; building has considerable ornamentation inside and out; principally alternating current apparatus with auxiliary direct current equipment.

134. Middle West, modern; includes (besides boilers, engine generators and air compressors), induced draft apparatus, coal and ash handling apparatus, hydraulic plant, etc.

135. Middle West, modern; a very complete plant both mechanically and architecturally.

136 Middle West, modern; large enough to allow for a one-third increase in capacity of the plant.

137. East, modern; fireproof construction throughout.

138. West, modern; a simple but effective plant limited to direct current, no coal or ash handling apparatus.

139. Middle West, modern; condensing equipment.

### ERECTING AND MACHINE SHOPS.

| Item. | Cost per Sq. Ft. of Ground Area. Building Only. | Tools. | Misc. Eqpt. | Total. | Cost per Cu. Ft. Building. Only. | Total. |
|---|---|---|---|---|---|---|
| 140 | 3.50 | 1.08 | .71 | 5.34 | .076 | .115 |
| 141 | 1.03 | 2.49 | .187 | 3.70 | .034 | .123 |
| 142 | .706 | 1.78 | .. | .. | .029 | .. |
| 143 | 1.67 | 2.05 | .086 | 3.79 | .051 | .118 |
| 144 | 2.43 | .81 | .. | .. | .051 | .. |
| 145 | 1.65 | 2.69 | .. | .. | .041 | .. |
| 146 | 1.80 | 1.65 | .. | .. | .046 | .. |
| 147 | 1.82 | .. | .. | .. | .050 | .. |
| 148 | 3.08 | 1.63 | .. | .. | .073 | .. |

NOTES.

140. East, modern; brick and steel, transverse shop, erecting shop has both heavy and light cranes; machine shop has crane service throughout; saw-tooth roof.

141. Middle West, old; brick and wood, transverse shop in two parts, one part one story with slate roof, the other part two stories with gravel roof.

142. Middle West, old; stone and wood, transverse shop, gravel roof supported by posts.

143. Middle West, old; brick with wood and iron roof trussing and shingle roof, longitudinal shop, machine shop on one side, traveling cranes in erecting shop.

144. Middle West, modern; brick and steel, transverse shop, high for two-thirds of width, with heavy crane, the remaining one-third being low, with saw-tooth roof.

145. Middle West three-fourths old, one-fourth new, brick and steel, transverse shop, new part two stories; no traveling cranes.

146. Pacific Northwest, modern; brick and steel, overhead crane.

147. Pacific Southwest, modern; brick and steel, overhead crane.

148. Far West, modern; brick and steel, overhead crane.

### ERECTING, MACHINE, BOILER AND TANK SHOPS.

| Item. | Cost per Sq. Ft. of Ground Area. Building Only. | Tools. | Misc. Eqpt. | Total. | Cost per Cu. Ft. Building Only. | Total. |
|---|---|---|---|---|---|---|
| 149 | 1.35 | .966 | .336 | .. | .033 | .. |
| 150 | 2.20 | .. | .. | .. | .. | .. |
| 151 | 1.91 | .. | .. | .. | .. | .. |
| 152 | 2.42 | 1.50 | .866 | 4.79 | .051 | .101 |
| 153 | 1.63 | .. | .. | 2.00 | .017 | .021 |
| 154 | .58 | 1.48 | .246 | 2.31 | .033 | .132 |

NOTES.

149. Middle West, modern; steel and brick, longitudinal shop, machine shop on one side, boiler shop on other side, crane runways throughout.

150. East, modern; brick and steel, longitudinal shop, machine shop on one side, boiler and tank shop on other side; crane runways. (These figures should be used with caution, as they are not official, but were taken from a published statement.)

151. Middle West, modern; brick and steel, longitudinal shop, machine shop on each side (one side two stories), wings have saw-tooth roof; boiler and tank shop is a continuation of erecting and machine shop; crane runways throughout.

152. Middle West, modern; brick and steel, transverse shop; erecting shop has both heavy and light crane, machine shop has partial crane service and boiler shop full crane service.

153. East, modern; brick and steel, longitudinal shop; heavy cranes in erecting shop, crane over one bay of machine shop; boiler and tank shop is a continuation of erecting and machine shops with joint crane service.

154. Middle West, old; wood, transverse shop, no overhead cranes.

### ERECTING, MACHINE, BOILER, SMITH AND WHEEL SHOP.

| Item. | Cost per Sq. Ft. of Ground Area. Building Only. | Tools. | Misc. Eqpt. | Total. | Cost per Cu. Ft. Building Only. | Total. |
|---|---|---|---|---|---|---|
| 155 | 2.60 | 1.33 | .475 | 4.42 | .046 | .079 |

NOTE.

155. Far West, modern; transverse shop, concrete, brick and steel, three fire walls, gravel roof, cranes in both erecting and machine shops.

### ERECTING, MACHINE, BOILER, SMITH SHOP AND POWER PLANT.

| Item. | Cost per Sq. Ft. of Ground Area. Building Only. | Tools. | Misc. Eqpt. | Total. | Cost per Cu. Ft. Building Only. | Total. |
|---|---|---|---|---|---|---|
| 156 | 2.20 | 1.39 | 1.38 | 4.97 | .050 | .114 |

NOTE.

156. West, modern; brick and steel, transverse shop, gravel roof; erecting and machine shop, also boiler shop, same cross section, power plant and smith shop same width but lower; crane equipment erecting and machine shops.

### MACHINE SHOP.

| Item. | Cost per Sq. Ft. of Ground Area. Building Only. | Tools. | Misc. Eqpt. | Total. | Cost per Cu. Ft. Building Only. | Total. |
|---|---|---|---|---|---|---|
| 157 | .952 | .. | .. | .. | .038 | .. |

NOTE.

157. Middle West, old; brick and wood, gravel roof supported by posts.

### BOILER AND TANK SHOPS.

| Item. | Cost per Sq. Ft. of Ground Area. Building Only. | Tools. | Misc. Eqpt. | Total. | Cost per Cu. Ft. Building Only. | Total. |
|---|---|---|---|---|---|---|
| 158 | 2.98 | .72 | 84 | 4.54 | .083 | .127 |
| 159 | 1.58 | .40 | .. | .. | .049 | .. |
| 160 | .84 | .94 | .076 | 1.87 | .033 | .075 |
| 161 | 1.66 | .48 | .083 | 2.24 | .059 | .080 |
| 162 | .99 | .. | .. | .. | .025 | .. |
| 163 | 1.53 | .96 | .. | .. | .095 | .. |

NOTES.

158. East, modern; brick and steel, cranes cover entire floor, saw-tooth roof.

159. Middle West, modern; brick and steel, one-half of width high for crane service, the other half lower and without cranes.

160. Middle West, old; brick and wood, with slate roof.

161. Middle West, old; brick and wood, shingle roof, gallery along one side, cranes over part of floor space.

162. Pacific Southwest, modern; brick and steel, overhead crane, smith shop in one end.

163. Middle West, two-thirds old, one-third new; brick and wood, new part two stories, no overhead cranes. (?)

### SMITH SHOPS.

| Item. | Cost per Sq. Ft. of Ground Area. Building Only. | Tools. | Misc. Eqpt. | Tools. | Cost per Cu. Ft. Building Only. | Total. |
|---|---|---|---|---|---|---|
| 164 | .. | .734 | .110 | .. | .. | .. |
| 165 | 2.63 | .982 | .171 | 3.78 | .080 | .115 |
| 166 | 1.79 | 1.44 | .. | .. | .049 | .. |
| 167 | .432 | 2.26 | .086 | 2.77 | .019 | .126 |
| 168 | 1.06 | 1.09 | .050 | 2.22 | .035 | .074 |
| 169 | 2.25 | .. | .. | .. | .. | .. |
| 170 | 1.43 | .665 | .435 | .. | .042 | .. |
| 171 | 1.50 | .. | .. | .. | .. | .. |
| 172 | 2.37 | 1.96 | .348 | 4.68 | .052 | .104 |
| 173 | 1.21 | .. | .. | .. | .041 | .055 |
| 174 | 1.38 | .. | .. | .. | .. | .. |
| 175 | .91 | .60 | .. | .. | .031 | .. |

NOTES.

164. Middle West, old.
165. East, modern; brick and steel, high and light, thoroughly equipped.
166. Middle West, modern; brick and steel, 100 ft. wide, hip roof without posts.
167. Middle West, old; brick and wood, with slate roof.
168. Middle West, old; brick and wood, shingle roof.
169. Southeast, modern; brick and steel, unusually high (33 ft. from floor to lower chord of roof truss). (These figures should be used with caution, as they are not official, but were taken from a published statement.)
170. Middle West, modern; brick and steel.
171. Middle West, modern; brick and steel, tile and gravel roof.
172. Middle West, modern; brick and steel, brass foundry and car machine shop under same roof; equipment very complete.
173. East, modern; concrete and steel, 80-ft. span, no posts.
174. Northeast, modern; brick and wood, 60-ft. span, no posts, simple construction.
175. Middle West, two-thirds old, one-third new; brick and wood. (?)

IRON FOUNDRY.

| | Cost per Sq. Ft. of Ground Area. | | | | Cost per Cu. Ft. | |
|---|---|---|---|---|---|---|
| Item. | Building Only. | Tools. | Misc. Eqpt. | Total. | Building Only. | Total. |
| 176 | 3.18 | .. | .. | .. | .. | .. |

NOTE.

176. Brick and steel, modern; U. S. Navy Yard, Bremerton, Wash.

IRON AND WHEEL FOUNDRY.

| | Cost per Sq. Ft. of Ground Area. | | | | Cost per Cu. Ft. | |
|---|---|---|---|---|---|---|
| Item. | Building Only. | Tools. | Misc. Eqpt. | Total. | Building Only. | Total. |
| 177. | .711 | .. | .432 | .. | .024 | .. |

NOTE.

177. Middle West, old; wooden building; cost includes several annexes. (?)

PATTERN AND UPHOLSTERY SHOP.

| | Cost per Sq. Ft. of Ground Area. | | | | Cost per Cu. Ft. | |
|---|---|---|---|---|---|---|
| Item. | Building Only. | Tools. | Misc. Eqpt. | Total. | Building Only. | Total. |
| 178 | .857 | .. | .131 | .988 | .043 | .050 |

NOTE.

178. Middle West, old; wooden building, two stories.

PASSENGER CAR REPAIR SHOPS.

| | Cost per Sq. Ft. of Ground Area. | | | | Cost per Cu. Ft. | |
|---|---|---|---|---|---|---|
| Item. | Building Only. | Tools. | Misc. Eqpt. | Total. | Building Only. | Total. |
| 179 | 1.24 | .. | .016 | 1.25 | .042 | .043 |
| 180 | 1.20 | .. | .. | .. | .. | .. |
| 181 | 2.64 | .044 | .096 | 2.78 | .099 | .105 |
| 182 | 1.34 | .. | .015 | 1.35 | .056 | .057 |
| 183 | .68 | .003 | .057 | .74 | .026 | .028 |
| 184 | .83 | .. | .. | .. | .029 | .. |

NOTES.

179. Middle West, modern; longitudinal shop, brick and wood.
180. Southeast, modern; transverse shop, brick and wood; has upholstery and cabinet shops under same roof. (These figures should be used with caution, as they are not official, but were taken from a published statement.)
181. Middle West, modern; transverse shop, brick and steel; includes upholstery and trimming shop and hot-air heating.
182. East, modern; transverse shop, brick and steel, with cement foundations, saw-tooth wooden roof.
183. Southeast, modern; transverse shop, brick up to window sills, corrugated galvanized iron sheathing on wooden frame above, gravel roof, granolithic floor, used also for painting and varnishing. (Identical with Passenger Car Paint Shop No. 193.)
184. Middle West, old; brick and wood. (?)

PASSENGER CAR PAINT SHOPS.

| | Cost per Sq. Ft. of Ground Area. | | | | Cost per Cu. Ft. | |
|---|---|---|---|---|---|---|
| Item. | Building Only. | Tools. | Misc. Eqpt. | Total. | Building Only. | Total. |
| 185 | 1.24 | .. | .004 | 1.24 | .04 | .04 |
| 186 | 1.94 | .055 | .092 | 2.09 | .072 | .078 |
| 187 | 1.02 | .. | .. | .. | .033 | .. |
| 188 | 1.20 | .. | .. | .. | .. | .. |
| 189 | 1.01 | .. | .039 | 1.05 | .035 | .036 |
| 190 | .35 | .. | .. | .. | .. | .. |
| 191 | 2.36 | .009 | .056 | 2.43 | .081 | .084 |
| 192 | 1.13 | .. | .009 | 1.14 | .051 | .052 |
| 193 | .68 | .003 | .057 | .74 | .026 | .028 |
| 194 | .89 | .. | .. | .. | .032 | .. |

NOTES.

185. Middle West, modern; longitudinal shop, brick and wood.
186. East, modern; longitudinal shop, brick and steel, saw-tooth roof, hot-air heating.
187. Pacific Southwest, modern; transverse shop, brick and steel.
188. Southeast, modern; transverse shop, brick and wood; has varnish room and pipe shop under same roof. (These figures should be used with caution, as they are not official, but were taken from a published statement.)
189. Northeast, modern; longitudinal shop, brick and steel; includes small paint, varnish and boiler rooms at one end.
190. South, old; wooden structure.
191. Middle West, modern; transverse shop, brick and steel; includes cleaning room, varnish room and hot-air heating.
192. East, modern; transverse shop, brick and steel, with cement foundations, saw-tooth wooden roof.
193. Southeast modern; transverse shop, brick up to window sills, corrugated galvanized iron sheathing on wooden frame above; gravel roof, granolithic floor; used also for coach repairs. (Identical with Passenger Car Repair Shop No. 183.)
194. Middle West, old; brick and wood. (?)

FREIGHT CAR REPAIR SHOPS.

| | Cost per Sq. Ft. of Ground Area. | | | | Cost per Cu. Ft. | |
|---|---|---|---|---|---|---|
| Item. | Building Only. | Tools. | Misc. Eqpt. | Total. | Building Only. | Total. |
| 195 | .40 | .. | .016 | .415 | .022 | .023 |
| 196 | 2.12 | .123 | .047 | 2.29 | .075 | .080 |
| 197 | .29 | .. | .. | .29 | .015 | .015 |

NOTES.

195. Middle West, old; wooden building, longitudinal, entirely enclosed.
196. Middle West, modern; brick and steel, longitudinal; includes cabinet shop and hot-air heating.
197. Middle West, old; large shop, longitudinal; construction not known, but probably wood with partly open sides.

CAR SHOP, PAINT SHOP, PLANING MILL, CABINET SHOP, UPHOLSTERY SHOP.

| | Cost per Sq. Ft. of Ground Area. | | | | Cost per Cu. Ft. | |
|---|---|---|---|---|---|---|
| Item. | Building Only. | Tools. | Misc. Eqpt. | Total. | Building Only. | Total. |
| 198 | 1.48 | .302 | .216 | 2.00 | .071 | .095 |

NOTE.

198. West, modern; brick and steel, transverse shop; gravel roof with central posts; car shop (for both passenger and freight) and paint shop, one-story, remainder of building two-story, with cabinet shop and upholstery shop over planing mill.

CAR SMITH AND CAR MACHINE SHOP.

| | Cost per Sq. Ft. of Ground Area. | | | | Cost per Cu. Ft. | |
|---|---|---|---|---|---|---|
| Item. | Building Only. | Tools. | Misc. Eqpt. | Total. | Building Only. | Total. |
| 199 | .77 | 1.06 | .. | .. | .028 | .. |

NOTE.

199. Middle West, old; brick and wood. (?)

WHEEL AND AXLE SHOP.

| | Cost per Sq. Ft. of Ground Area. | | | | Cost per Cu. Ft. | |
|---|---|---|---|---|---|---|
| Item. | Building Only. | Tools. | Misc. Eqpt. | Total. | Building Only. | Total. |
| 200 | 4.03 | 2.16 | .72 | 6.91 | .16 | .276 |

NOTE.

200. West, modern; brick and steel, for car work only.

CAR REPAIR SHOP AND PLANING MILL.

| | Cost per Sq. Ft. of Ground Area. | | | | Cost per Cu. Ft. | |
|---|---|---|---|---|---|---|
| Item. | Building Only. | Tools. | Misc. Eqpt. | Total. | Building Only. | Total. |
| 201 | .975 | .. | .. | .. | .031 | .. |

NOTE.

201. Pacific Southwest, modern; brick and steel; has intermediate two-story section for sub-departments.

PLANING MILLS.

| | Cost per Sq. Ft. of Ground Area. | | | | Cost per Cu. Ft. | |
|---|---|---|---|---|---|---|
| Item. | Building Only. | Tools. | Misc. Eqpt. | Total. | Building Only. | Total. |
| 202 | .487 | .54 | .010 | 1.04 | .026 | .056 |
| 203 | 1.15 | 1.18 | .25 | 2.58 | .045 | .102 |
| 204 | .76 | 1.21 | .292 | 2.26 | .033 | .098 |
| 205 | 1.85 | .. | .. | .. | .. | .. |
| 206 | .37 | .. | .. | .. | .. | .. |
| 207 | 2.54 | 1.44 | .082 | 4.06 | .095 | .153 |
| 208 | 2.53 | .558 | .. | .. | .057 | .. |
| 209 | .39 | .50 | .. | .. | .014 | .. |
| 210 | .74 | .485 | .239 | 1.47 | .037 | .073 |

NOTES.

202. Middle West, old; wooden building, tools and equipment very light.
187. Pacific Southwest, modern; transverse shop, brick and steel. vanized iron on insulated wooden frame, basement and one story, grav roof, mechanical power plant in annex, cabinet shop in wing.
204. Middle West, old; brick and wood, slate roof.
205. Southeast, modern; steel and brick. (These figures should be used with caution, as they are not official, but were taken from a published statement.)
206. South, old; wooden structure.
207. Middle West, modern; brick and steel; does not include cabinet shop, which is separate.
208. Middle West, old; brick and wood; includes pattern shop. (?)
209. Middle West, old; wooden building. (?)
210. West, modern; wooden. (?)

## STOREHOUSES.

| Item. | Cost per Sq. Ft. of Ground Area. Building Only. | Tools. | Misc. Eqpt. | Total. | Cost per Cu. Ft. Building Only. | Total. |
|---|---|---|---|---|---|---|
| 211 | 1.142 | .. | .168 | 1.31 | .044 | .050 |
| 212 | 3.60 | .. | .. | .. | .. | .. |
| 213 | 3.05 | .. | .67 | 3.72 | .073 | .089 |
| 214 | 2.40 | .. | .. | 2.72 | .110 | .124 |
| 215 | 2.00 | .. | .. | .. | .050 | .. |

NOTES.

211. Southeast, modern; brick up to window sills, then corrugated galvanized iron on unsheathed wooden frame; two stories, gravel roof, platform, bins, shelves, etc., complete.

212. Southeast, modern; brick and steel, two stories and basement, extensive offices in one end on both floors. (These figures should be used with caution, as they are not official, but were taken from a published statement.)

213. Middle West, modern; brick and wood, three stories.

214. East, modern; concrete construction, one end two stories, upper floor used for offices.

215. Middle West, old; brick and wood, two stories. (?)

## OIL HOUSES.

| Item. | Cost per Sq. Ft. of Ground Area. Building Only. | Tools. | Misc. Eqpt. | Total. | Cost per Cu. Ft. Building Only. | Total. |
|---|---|---|---|---|---|---|
| 216 | 5.41 | .. | 1.43 | 6.84 | .208 | .263 |
| 217 | 3.52 | .. | 1.55 | 5.07 | .196 | .302 |
| 218 | 1.33 | .. | .. | .. | .089 | .. |
| 219 | 2.15 | .. | 1.34 | 3.49 | .097 | .159 |

NOTES.

216. Middle West, modern; brick and steel, basement and one story, full equipment of tanks, etc.

217. East, modern; concrete walls and roof, one story with deep basement.

219. West, modern; brick and steel, tile roof, two stories.

## ROUNDHOUSES.

| Item. | Number of Stalls. | Cost per Stall. Building Only. | Tools. | Misc. Eqpt. | Total. |
|---|---|---|---|---|---|
| 220 | 18 | 1,388.88 | ..... | ..... | ..... |
| 221 | 46 | 1,155.00 | ..... | ..... | ..... |
| 222 | 10 | 2,400.00 | ..... | ..... | ..... |
| 223 | 10 | 1,757.70 | ..... | ..... | 2,090.60 |
| 224 | 30 | ..... | ..... | ..... | 1,500.00 |
| 225 | 13 | 1,040.00 | ..... | ..... | ..... |
| 226 | 8 | 2,750.00 | ..... | ..... | ..... |
| 227 | 7 | 1,033.00 | ..... | ..... | ..... |
| 228 | 33 | ..... | ..... | ..... | 2,200.00 |
| 229 | .. | ..... | ..... | ..... | 1,845.00 |
| 230 | 44 | 1,998.00 | 133.00 | 328.00 | 2,459.00 |
| 231 | 30 | 4,150.00 | ..... | ..... | ..... |
| 232 | 25 | 1,950.00 | ..... | ..... | 2,455.00 |
| 233 | 48 | 2,480.00 | ..... | ..... | ..... |
| 234 | 25 | 1,719.00 | ..... | ..... | ..... |
| 235 | 18 | 1,011.00 | ..... | ..... | ..... |
| 236 | 23 | 1,065.00 | ..... | ..... | ..... |
| 237 | 44 | 1,740.00 | ..... | ..... | ..... |
| 238 | 40 | 1,875.00 | 87.50 | 787.50 | 2,750.00 |

NOTES.

220. Middle West, old; 63-ft. span, brick and wood, slate roof, trussed (no posts).

221. Pacific Southwest, modern; 80-ft. span, brick and wood, roof supported by posts.

222. Far West, modern; part 75-ft. span, part 85-ft. span, brick and wood, gravel roof, supported by posts.

223. Far West, modern; 85-ft. span, brick and wood, gravel roof, supported by posts.

224. Middle West, old; 65-ft span, brick and wood, gravel roof, supported by posts.

225. Middle West, old; 78-ft. span, brick and wood, gravel roof, supported by posts.

226. Middle West, modern; 89-ft. span, brick and wood, gravel roof, supported by posts.

227. Middle West, old; 80-ft. span, brick and wood, gravel roof, supported by posts.

228. East, modern; 81-ft. span, brick and steel, gravel roof, supported by flat truss (no posts), rolling steel doors; cost does not include heating equipment.

229. Northwest, modern; 80-ft. span, brick and wood, gravel roof, supported by posts, annex with boilers, heating apparatus (hot air), and air compressor.

231. East, modern; 90-ft. span, brick and steel, slag roof, with crane runway covering outer half of span; has very heavy pile and stone foundations.

232. East, modern; 80-ft. span, concrete and wood, gravel roof, supported by posts.

233. Northeast, modern; 75-ft. span, brick and wood, gravel roof, supported by posts.

234. Northeast, modern; 75-ft. span, brick and wood, gravel roof, supported by posts.

235. Northeast, modern; 72-ft. span, brick and wood, gravel roof, supported by posts.

236. West, modern; 80-ft. span, brick and wood gravel roof, supported by posts.

237. Middle West, part old, part modern; 70-ft. and 85-ft. span, gravel roof, supported by posts. (?)

## LAVATORY.

| Item. | Cost per Sq. Ft. of Ground Area. Building Only. | Tools. | Misc. Eqpt. | Total. | Cost per Cu. Ft. Building Only. | Total. |
|---|---|---|---|---|---|---|
| 239 | .. | .. | .. | 2.55 | .. | .. |

NOTE.

239. Middle West, modern; average of three large lavatories (including water closets, urinals, washroom and locker-rooms); buildings of concrete and brick, with tile roofs and wooden trusses; cement floors, complete with contents, ready to use.

## OFFICE BUILDINGS.

| Item. | Cost per Sq. Ft. of Ground Area. Building Only. | Tools. | Misc. Eqpt. | Total. | Cost per Cu. Ft. Building Only. | Total. |
|---|---|---|---|---|---|---|
| 240 | .306 | .. | .. | .. | .030 | .. |
| 241 | 8.01 | .557 | .295 | 8.86 | .167 | .187 |
| 242 | 1.04 | .. | .. | .. | .034 | .. |

NOTES.

240. Middle West, old; frame building with brick foundation, includes M. M. store department, steam heat.

241. Middle West, modern; brick and wood, basement, two stories and attic, ornamental architecture.

242. Middle West, old; wooden, two stories and basement. (?)

## TRACK.

| Item. | Cost per Lin. Ft. | Add. for Each Switch. | Notes. |
|---|---|---|---|
| 243 | 0.70 | 170.00 | Based on use of "fit" (second-hand), 67-lb. rail. |
| 244 | 1.00 | 180.00 | Based on use of "fit" (second-hand), 85-lb. rail. |
| 245 | 1.00 to 1.25 | 75.00 to 125.00 | Based on use of new rail, according to weight. |

## TURNTABLES.

| Item. | Diameter. | Cost. | Notes. |
|---|---|---|---|
| 246 | 70 ft. | $3,000 | Exclusive of pit. |
| 247 | 70 ft. | 5,091 | Including pit. (?) |

## TRANSFER PITS AND TABLES.

| Item. | Cost per Square Foot of Pit. Pit. | Table. | Total. | Notes. |
|---|---|---|---|---|
| 248 | .31 | .17 | .48 | Far West, modern; to handle the heaviest class of engines. |
| 249 | .43 | .16 | .59 | East, modern; pit of concrete throughout; capacity of the table, 200 tons. |

## MISCELLANEOUS STRUCTURES.

| Item. | Name. | Cost. | Notes. |
|---|---|---|---|
| 250 | Ash pit ..... | $30.20 per lineal ft. | |
| 251 | Coal chute ..... | .65 per sq. ft... | Two-sided, with trestle approach. (?) |
| 252 | Water tank ..... | 1,900.00 total .... | 50,000-gal. capacity, on timber trestle. |
| 253 | Water pipe, underground laid ..... | 1.43 per lin. ft. | Large system, pipes from 12-in. down to 4-in. |
| 254 | Sewer pipe, underground laid ..... | 2.88 per lin. ft. | Large system, pipes from 24-in. down to 12-in. |
| 255 | Long lines of wrought-iron pipe (for air, gas or water), with usual proportion of valves, fittings, etc., in place..... | 25.00 pr. 100 ln. ft.<br>45.00 pr. 100 ln. ft.<br>85.00 pr. 100 ln. ft.<br>130.00 pr. 100 ln. ft. | *1-in. diameter.<br>*2-in. diameter.<br>*3-in. diameter.<br>*4-in. diameter. |

*Given by a large pipe-contracting firm of Pittsburgh.

## MINOR BUILDINGS.

| Item. | Name. | Cost per Sq. Ft. | Cost per Cu. Ft. | Notes. |
|---|---|---|---|---|
| 256 | Iron storehouse .... | .24 | .011 | Old, wooden. (?) |
| 257 | Brass foundry ..... | 1.96 | .098 | Old, brick and wood. (?) |
| 258 | Upholstery shop .... | .58 | .029 | Old, brick and wood (?) |
| 259 | Paint-mixing shop.. | .58 | .029 | Old, brick and wood (?) |
| 260 | Paint storehouse ... | 1.75 | .087 | Old, brick and wood. (?) |
| 261 | Freight repair shed. | .11 | ... | New, wooden, open sides. (?) |
| 262 | Dry kiln ..... | .79 | .039 | Old, wooden. (?) |
| 263 | Lumber shed ..... | .21 | ... | Old, wooden, open sides. (?) |
| 264 | Storehouse shed .... | .31 | .015 | Old, wooden. (?) |
| 265 | Coal shed ..... | .24 | .020 | Old, wooden. (?) |
| 266 | Coal shed ..... | .25 | .021 | Old, wooden. (?) |
| 267 | Charcoal shed ..... | .21 | .017 | Old, wooden. (?) |
| 268 | Ice house ..... | .57 | .028 | Old, wooden. (?) |
| 269 | Ice house ..... | .60 | .030 | Old, wooden. (?) |
| 270 | Crematory ..... | 2.52 | .210 | |
| 271 | Small office building | .50 | ... | Old, wooden, one-story. |

It is believed that in most cases the cost of a proposed shop will be asked for as soon as the layout plan has been completed, and that the following is the best basis for making an estimate:

List up all the buildings, with their ground area in square feet; all the miscellaneous structures, either on the square foot, the lineal foot or the unit basis (as may appear best); all the track on the lineal foot basis, the turnouts on the unit basis, etc.; assign a unit price to each item, as determined by the special local conditions; carry out the cost extensions, and totalize. To the totals thus obtained add a percentage to cover incidentals and items not shown by the layout plan; this percentage may vary from a minimum of 10 per cent. to a maximmu of 25 per cent., according to the completeness of the layout plan and the degree of confidence which may be felt in the unit prices assumed. The grand total should represent the approximate cost of the plant, exclusive of the cost of land and grading, which should be estimated separately, these two items not being susceptible of reduction to a unit basis.

If the buildings have been designed in detail, their cost may be checked upon the cubic-foot basis.